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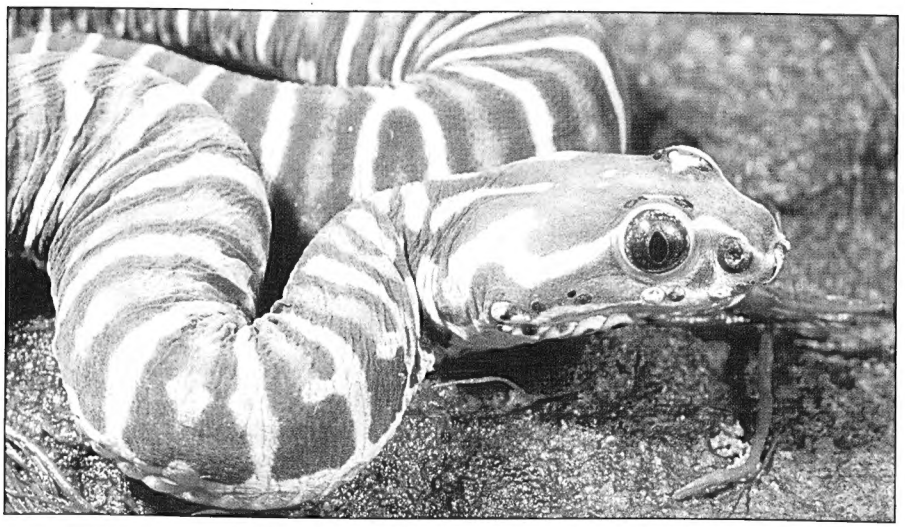
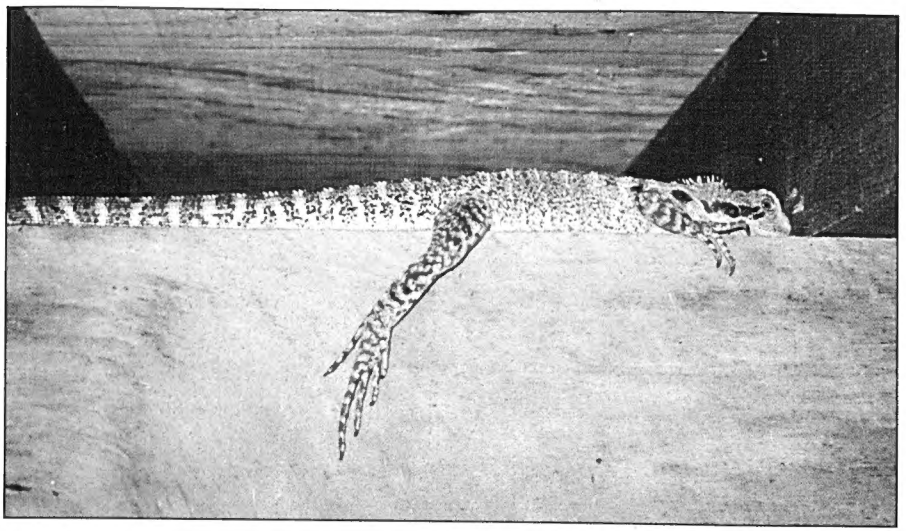


Death Adder (*Acanthophis antarcticus*) with scale agenesis. See paper on page 46.
(Photo by E. Vanderduys).



Eastern Water Dragon (*Physignathus lesueurii lesueurii*) from Banora Point, NSW sleeping on timber joist under house. See paper on page 33. (Photo by C. Hobden).

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CONTENTS

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HERPETOLOGICAL NOTES

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BREEDING AND MANAGEMENT OF THE GREAT BARRED FROG, *MIXOPHYES FASCIOLATUS*, AT MELBOURNE ZOO

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ABSTRACT

Melbourne Zoo has maintained the Great Barred Frog *Mixophyes fasciolatus* since 1994. Animals were acquired as tadpoles and metamorphlings, and raised to adults which subsequently reproduced. This species was originally chosen as an analogue for the Stuttering Barred Frog *M. balbus*, which is Victoria's only species of *Mixophyes* and is listed as Vulnerable on Schedule 2 of the Threatened Species Conservation Act, 1995. Three spawnings of *M. fasciolatus* were achieved in 1998. Tadpole growth rates were monitored in 1998 according to density per volume of water and water temperature. A further nine spawnings occurred in 1999 and 2000. A number of captive-bred frogs suffered from metabolic bone disease, which was successfully treated and has since led to a Masters project at the Zoo to investigate nutritional osteodystrophy in sub-adult *M. fasciolatus*. From September 1998 to December 2000, almost 200 young frogs were transferred to eight other zoos and nine private individuals. These animals will provide the opportunity to develop husbandry knowledge and skills, with the long-term goal being for zoos to support captive programs for the threatened members of the genus.

INTRODUCTION

The genus *Mixophyes* comprises six species of Barred Frog, five of which occur in the moist coastal forests of eastern Australia and the other in the highland rainforests of New Guinea (Donnellan *et al.*, 1990; Tyler, 1992; Cogger, 2000). All are moderately large frogs, characterised by the presence of barred markings on the limbs. They are found in close association with streams, where their eggs are laid either in shallow flowing water or on wet surfaces close to the water's edge. Of the five species, *M. balbus* (Stuttering Barred Frog) is listed as Vulnerable, and *M. fleayi* (Fleay's Barred Frog) and *M. iteratus* (Giant Barred Frog) as Endangered on Schedule 2 of the Threatened Species Conservation Act, 1995 and in the Action Plan for Australian Frogs (Stanger *et al.*, 1998; Tyler, 1997). The decline of these three species has emphasised the need to adopt actions to ensure their continued survival. Hence, a Draft Recovery Plan has been formulated outlining their natural biology, research and management actions undertaken, possible threatening causal factors and recovery actions needed (NPWS, in press).

The Draft Recovery Plan also calls for the establishment of captive husbandry protocols for the three species, in the event that these are needed at some point in the future (NPWS, in press). This proposal was picked up by Australian zoos in 1996, when the genus *Mixophyes* was the first group of frogs to be addressed as a priority taxon for regional captive management. A co-ordinator for the group was assigned and a Taxon Management Account (TMA) drawn up covering eight main areas, i.e. Introduction, Natural History, Conservation Status, Captive History, Captive Management, Reproduction, Comments and References (Porter, 1998). This development followed the 1992 inclusion of Australian frogs in the "Taxon Advisory Group (TAG) Action Plan for Reptiles and Amphibians in Australasian Zoos" (Banks, 1993). Emphasis was placed on developing new, and upgrading current facilities, with the overall aim of developing standards for captive management and reproduction (Banks & Meikle, 1994; Banks, 1999).

In 1993 an amphibian facility was constructed at Melbourne Zoo to meet the recommendations outlined in the TAG Action Plan

(Banks, 1995). Its function was to exhibit amphibians and develop husbandry protocols and techniques, with an emphasis on creating greater visitor awareness of amphibians. The facility is a small complex, consisting of seven exhibits and two small off-limit holding rooms, ie. a room for tropical frogs and another for temperate frogs. The building is set beside a man-made wetland encompassing a sound-scape of frog calls of the Melbourne area.

When formulating the collection plan for the new facility, *M. balbus*, was foreseen as a species in need of attention. It was the only member of the genus to naturally occur in Victoria and has suffered a dramatic reduction in the southern parts of its distribution, particularly in Victoria, where it has only been observed on three occasions in the last 30 years, the last sighting being in 1984 (Gillespie & Hines, 1999). As part of a long-term project to establish and maintain a captive population of *M. balbus* at Melbourne Zoo, the Great Barred Frog *M. fasciolatus*, was chosen as an analogue to develop husbandry practices before taking on the rarer *M. balbus*.

From 1993-95, 12 metamorphling *M. fasciolatus* were acquired from Lone Pine Sanctuary (Brisbane), the Amphibian Research Centre (Melbourne) and Gondwana Sanctuary (Brisbane). Eight of these animals formed the two original breeding groups.

METHODS

Two groups of 2:2 (two males:two females) and 3:1 (three males:one female) adult *M. fasciolatus* were maintained in three glass aquaria, each measuring 1800 x 450 x 450 mm, which are designed to replicate a cross section of a flowing stream (Fig. 1). Each tank consisted of two areas of deep substrate for burrowing, separated by a water body. The deep litter substrate comprised palm peat to a depth of 300 mm, positioned on a shallow layer of aquarium gravel on fly mesh and raised approximately 50 mm from the base to assist with drainage. The palm peat was regularly flushed and occasionally turned to assist with aeration. Both tanks were located beside each other within an off-limit holding area in Melbourne Zoo's Reptile House, where ambient air temperatures ranged from 21-26°C throughout the year.

The water was filtered by a wet trickle filter and pumped by an aquarium power-head, with the water input pipe positioned out of the water on rocks to create a splash zone. Rocks and logs were placed along the water's edge to create a selection of oviposition sites.

Polaroid photographs of the dorsal patterns were used to identify individual adult frogs. Males were sexed by calling behaviour, presence of nuptial pads and darker colouration of the gular region.

From December 1997 to November 1998, barometric and rainfall charts were downloaded daily from the Bureau of Meteorology website. Daily data sheets using this information were designed and any frog behaviour, e.g. calling, amplexus and spawning, was recorded onto the respective day's weather chart. A voice-activated recorder was also used to record overnight calling activity. A rain chamber on a timer was used each day (usually for two hours in the afternoon and at night) for six days in early April 1998. This consisted of a plastic tub, measuring 500 x 300 x 250 mm, with small holes drilled in the base. The return hose from the filter was redirected into the tub and the drain hole in the base of the land area was initially blocked to create a flooded environment.

Three groups of tadpoles from the first spawning in 1998 were placed into separate all-glass tanks (450 x 530 x 150 mm) in both of the off-limit frog rooms in the Zoo's "World of Frogs" facility. Tadpole tanks were designed with overflow pipes that had grill covers to prevent tadpoles from being flushed down the drain. Water changes were conducted every second day by leaving the hose flowing into each tank until the water was clear. Each of the tanks had an air-stone for increased aeration of the water. Two groups, each of approximately 150 tadpoles, were maintained in 26 litres of water at different water temperatures, i.e. 16-20°C and 18-

22°C. These tadpoles were subsequently divided into four groups of 75 tadpoles each into tanks of the same water volume – G1 and G2 at 18-22°C, and G3 and G4 at 16-20°C. After a further two weeks, the four groups were moved into larger tanks, each still containing 26 litres of water.

The third group of 24 tadpoles (G5) was kept at 18-22°C in 26 litres of water as a density trial with the tadpoles in G1 and G2. These tadpoles were further separated into three groups of eight animals each, in tanks containing the same volume of water.

Tadpoles were fed *ad lib.* primarily on frozen endive, supplemented occasionally with Energen Tropical fish flake and Nutrafin pellets.

Water temperatures and measurements of tadpoles were recorded weekly. The largest tadpole from each group was selected and the total length measured with vernier callipers to the nearest mm while placed in a shallow glass petrie dish. Tadpole measurements ceased when the first tadpole was removed at the point of all four limbs emerging and specimens were then placed into small plastic containers (each measuring 300 x 210 x 105 mm) until the tails were fully reabsorbed. Weight and snout-vent lengths of the first 16 metamorphs from each group were recorded at the completion of metamorphosis.

Tadpoles were not separated into groups in 1999 and 2000, nor was their growth monitored to the same degree, but they were maintained in the same sized all-glass tanks, and cleaned and fed, as in 1998. Water temperature varied from 17-23°C.

To enhance public display potential, six young frogs bred at the Zoo were each placed in individual plastic aquaria (360 x 220 mm and 270 mm high) in an off-display area in the centre of the Reptile House, where they were constantly exposed to keeper presence. The frogs were initially provided with small pebbles (5-10 mm diameter) to a depth of 12 cm, as well as a small piece of fibreglass plant pot as shelter and a small water bowl (10 cm diameter). An additional ten young frogs were set up in a similar manner as they metamorphosed. Over a period of 6-12 months, the depth of the pebbles was gradually reduced to a depth that did not allow the frogs to burrow, as the frogs became used to the presence of keepers nearby and did not hide or jump. These frogs were maintained in these tanks for periods varying from 12-18 months.

One group of 4:3 frogs was placed in an outside enclosure measuring 3.0 x 3.0 m and 2.2 m high in a secure off-limit area adjacent to the Reptile House on 24 November 2000. The lower 800 mm of the walls was lined on the inside with colorbond sheeting. The upper sections of the walls, and the ceiling, were constructed of 5 x 5 mm wire mesh on a pine frame. The walls were dug into the ground to 30 cm depth and there was a layer of 5 x 5 mm steel mesh below ground to prevent entry by predators. The enclosure was naturally landscaped with a 1.0 x 0.5 m in-ground plastic pool, grasses, low bushes and branches, and logs and rocks. An insect-catcher (using a 100W light globe) was built into the ceiling to attract local insects as food for the frogs. Live crickets and grasshoppers were provided 2-3 times per week.

Another group of ten frogs was placed on public display in the World of Frogs. The exhibit measured 2.5 x 1.4 m and 1.1 m high, with moulded fibreglass walls and base. A waterfall flowed into a small rocky stream, which then flowed into a 30 cm deep pool (1.0 x 0.8 m surface area). The exhibit was landscaped with river stones, branches and riparian vegetation. Visitors viewed the frogs through the glass front of the exhibit, including below water, into the pool.

RESULTS

Spawning details

In 1998 males commenced calling sporadically throughout February and March, generally in association with weak cold fronts. Amplexus was observed on 13 February and 20 March, coinciding with approaching cold fronts, but spawning did not result. Calling behaviour intensified during the first two of

weeks of April, which prompted both groups of frogs to be put together on 12 April and a rain chamber set up in preparation for an approaching cold front. The rain chamber was left on during that day and both groups separated into their respective tanks by the end of the day. The pair of largest frogs was found to be in amplexus on the following morning after the strong cold front had passed. Spawning had commenced by mid-morning and by midday approximately 500 eggs had been laid in two clumps on a flat, water-soaked piece of timber overhanging the water, approximately 100 mm above the water's surface. A small number of eggs was found within a narrow cavity on wet rock, under the timber, and also some in the water. The water temperature was 22°C and pH 7.5.

After an incubation period of eight days, those eggs laid on wet surfaces hatched, with the embryos dropping directly into the water. Eggs left in the water failed to hatch, with development ceasing half way through incubation. Embryos measured 15 mm at the time of hatching.

Vigorous calling and male combat was recorded from April to May 1998, and four males were often recorded calling together. Amplexus was observed in both tanks on 19 and 28 April, 6, 15 and 17 May, and 10 July. Reproductive behaviour decreased by July and August, but recommenced in early September, with spawning in both tanks on the 24 September and 26 October. The adult frogs were measured and weighed once spawning had ceased (Table 1).

Oviposition sites in September and October were similar to that of the previous spawning (April). Both clutches consisted of approximately 300 eggs, which were indicative of the smaller size of the females. Like the first spawning, the second and third also coincided with the passing of low pressure systems, but without the added stimulus of a rain chamber.

During the third spawning, oviposition by the frogs was observed. While in amplexus, the female gathered the eggs with her back feet, whereupon she rolled to one side and with a quick flick of the foot, kicked the eggs onto a nearby wet vertical rock surface. The sticky, jelly-like capsule helped adhere the eggs to the wet surface. It is presumed that the eggs were fertilised by the male while being held in the female's feet just prior to being kicked onto the rock.

In 1999 and 2000, calling was heard from August to October and amplexus between frogs hatched at the Zoo in 1998 was observed during March, 2000. Spawning occurred in April (twice), October (once) and November (twice) in 1999; and once a month in February, July, August and November in 2000. Eggs were deposited on rocks and branches/bark at the water's edge, with water temperature being 21-23°C and pH 6.1-6.8. The eggs were not counted, but hatching occurred after 2-5 days.

Tadpole growth and density trial results

Results from the temperature trials on the growth rates of tadpoles hatched in 1998 showed little variation between G1 and G2 kept at warmer temperatures, and G3 and G4 kept at cooler temperatures (Fig. 2). However, times to metamorphosis did vary, with G3 and G4 taking longer (Table 2). Tadpoles from G1 and G2 commenced metamorphosis at 99 and 108 days post-hatching, respectively, whereas tadpoles from G3 and G4 started at 120 and 132 days respectively. The first signs of hind limb emergence also commenced a week earlier in G1 and G2, on 2 July, 1998. The total length of tadpoles prior to metamorphosis (Gosner stage 42; Gosner, 1960) ranged from 92-95 mm for G1 and G2, and 97-98 mm for G3 and G4. Tadpoles from G5 were the first to metamorphose out of the five groups, at 80 days post-hatching. Hind limbs in these tadpoles emerged from 18 June, 1998 and the total length of tadpoles at the time of metamorphosis ranged from 96-99 mm.

The average weights and total lengths of the first 16 metamorphs from each group showed that the smallest metamorphs were from G1 and the largest from G4 (Table 2). There was very little difference in weight or length of the metamorphs in G1, G2 and G3

(Figs. 3 & 4). The largest tadpole, measuring 125 mm, which developed into a frog weighing 11.5 g with a total length of 44 mm, came from G4. The tadpole with the longest period of larval development, 271 days, also came from G4.

Similar ranges for hatching to metamorphosis were recorded in 1999 and 2000, with the variation within each of two spawnings being 102-209 days (Spawn 99-A) and 91-160 days (Spawn 99-B). In both these instances, those tadpoles which took longer to metamorphose were larger at metamorphosis than those which metamorphosed over shorter periods:

Spawn 99-A:

Metamorphosis at 102 days: snout-urostyle length of 23-27 mm (mean 25 mm) and weight of 1.4-2.6 g (mean 1.8 g) (n = 12).

Metamorphosis at 209 days: snout-urostyle length of 35-37 mm (mean 36 mm) and weight of 3.9-4.6 g (mean 4.2 g) (n = 4).

Spawn 99-B:

Metamorphosis at 91 days: snout-urostyle length of 24-28 mm (mean 26 mm) and weight of 1.5-2.9 g (mean 2.2 g) (n = 13).

Metamorphosis at 160 days: snout-urostyle length of 29-33 mm (mean 31 mm) and weight of 2.5-3.7 g (mean 3.2 g) (n = 5).

Growth and management of young frogs

One group of frogs which hatched in July 1998 reached snout-urostyle lengths of 44-51 mm (mean 47.9 mm) and weights of 11.7-18.9 g (mean 15.6 g) (n = 12) after 205 days and 48-52 mm (mean 50.3 mm) and 18.6-28.7 g (mean 22.9 g) (n = 10) after 395 days.

The young frogs that were placed in the plastic aquaria to enhance their display potential were maintained under those conditions for periods ranging from 12-18 months, with certain individuals being added later than others, and frogs being moved to the public display or to other collections. Overall, the frogs that were placed on display sat out more during the day than other individuals, despite having ready access to hiding locations.

In December 1999, frogs which had metamorphosed nine months earlier were presented with clinically evident nutritional osteodystrophy, or metabolic bone disease (MBD), particularly affecting their long bones. Following veterinary examination and radiography to confirm the presence of MBD, parenteral calcium supplementation was commenced on 23 December 1999 in two of the frogs. This treatment consisted of administering 100 mg/kg calcium borogluconate solution subcutaneously every three days. After 26 days of treatment, four frogs were radiographed – two in the treatment group and two with confirmed MBD which were not receiving any treatment – to monitor response to treatment. There was no radiographic improvement in bone density, so treatment was continued in the two frogs.

Thirty four days after the treatment trial commenced, one of the frogs in the treatment group was found dead in its enclosure. A post-mortem was performed and samples were sent away for histopathological examination. The results obtained were highly suggestive of nutritional osteodystrophy as a result of hypovitaminosis D. Accordingly, the treatment of the surviving frog was modified to include vitamin D supplementation using oral Calcivet ® solution (Vetafarm Pty Ltd; vitamin D3, 25,000 IU/L; calcium borogluconate 33 g/L; magnesium sulfate 2 g/L) given at a dose rate of 100 IU vitamin D3/kg/week, based on published reptile dose rates (Wright & Whitaker, 1999). Three months later, on 19 May, 2001, radiographs were repeated on the treated frog, showing that, whilst the long bones remained abnormal in shape, there was a radiographically evident increase in overall bone density, suggesting improvement in the MBD in response to treatment.

The frogs placed in the outside enclosure on 24 November 2000 appeared to adjust well to their new surroundings and have since bred in the enclosure. However, no data on spawn or tadpoles were recorded and the

frogs did not readily show themselves. These frogs had hatched at the Zoo in February and August 1999.

The group of frogs placed on public exhibit has had mixed success, with some specimens, usually the larger frogs, sitting out on display. However, breeding has occurred in the exhibit, although no data were recorded on spawn or tadpoles.

Figure 1. Glass aquarium for adult *M. fasciolatus* at Melbourne Zoo

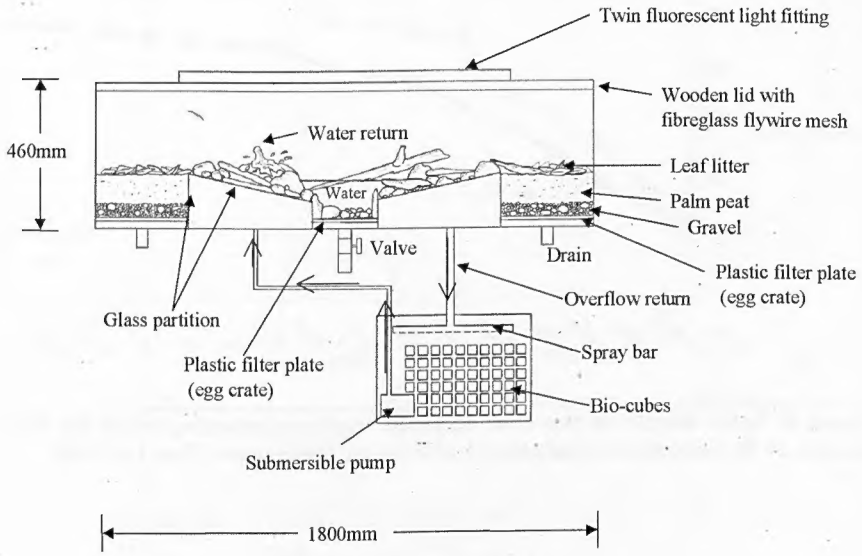


Table 1. Sizes of *M. fasciolatus* at amplexus at Melbourne Zoo

Pair #	Male		Female	
	Weight (g)	Snout-vent length (mm)	Weight (g)	Snout-vent length (mm)
1 13/04/1998	32.9	56.6	44.3	70.5
2 26/10/1998	37.0	58.0	33.8	60.0

Table 2. Time to start of metamorphosis (stage 42), length of metamorposis and metamorph weight and length, of M. fasciolatus at Melbourne Zoo

Group #	Time to start of metamorphosis (days)	Tadpole length at start of metamorphosis (mm)	Length of metamorphosis (days)	Av. metamorph length (mm)	Av. metamorph weight (g)
G1	99	92 - 95	8 - 12	30.12	3.64
G2	108	92 - 95	9 - 13	30.81	3.79
G3	120	97 - 98	9 - 15	30.81	3.75
G4	132	97 - 98	9 - 15	36.50	6.80
G5	80	96 - 99	5 - 10	32.81	4.82

Figure 2. Growth rate of *Mixophyes fasciolatus* tadpoles hatched at Melbourne Zoo in 1998.

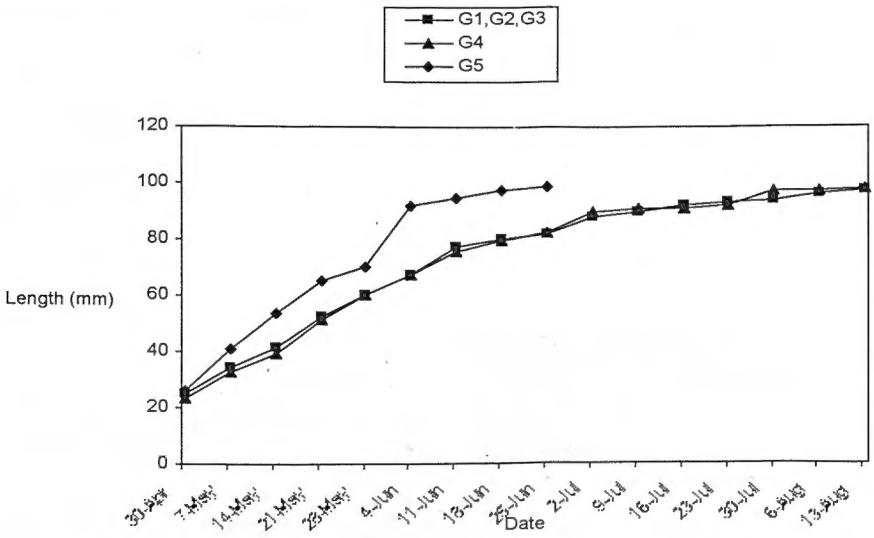


Figure 3. Total weight of the first 16 frogs metamorphosing from the five groups of *M. fasciolatus* tadpoles hatched at Melbourne Zoo in 1998.

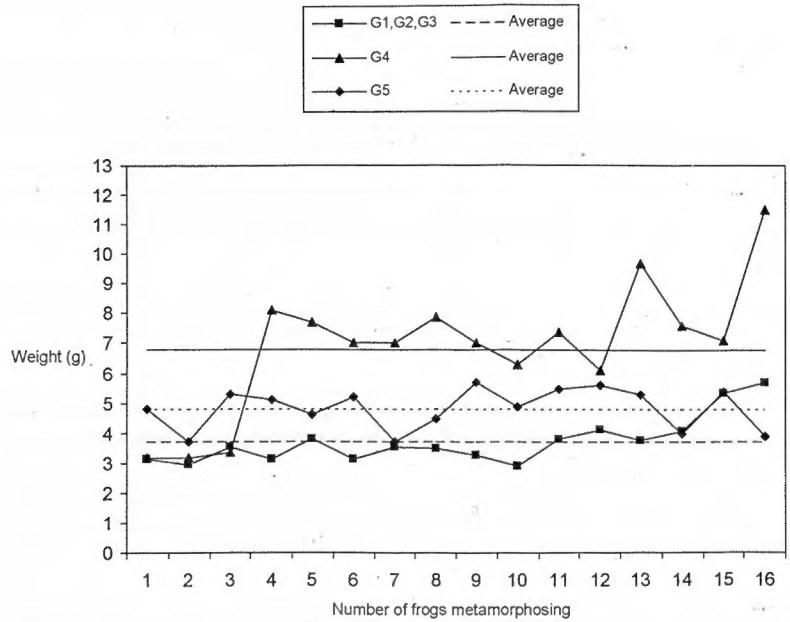
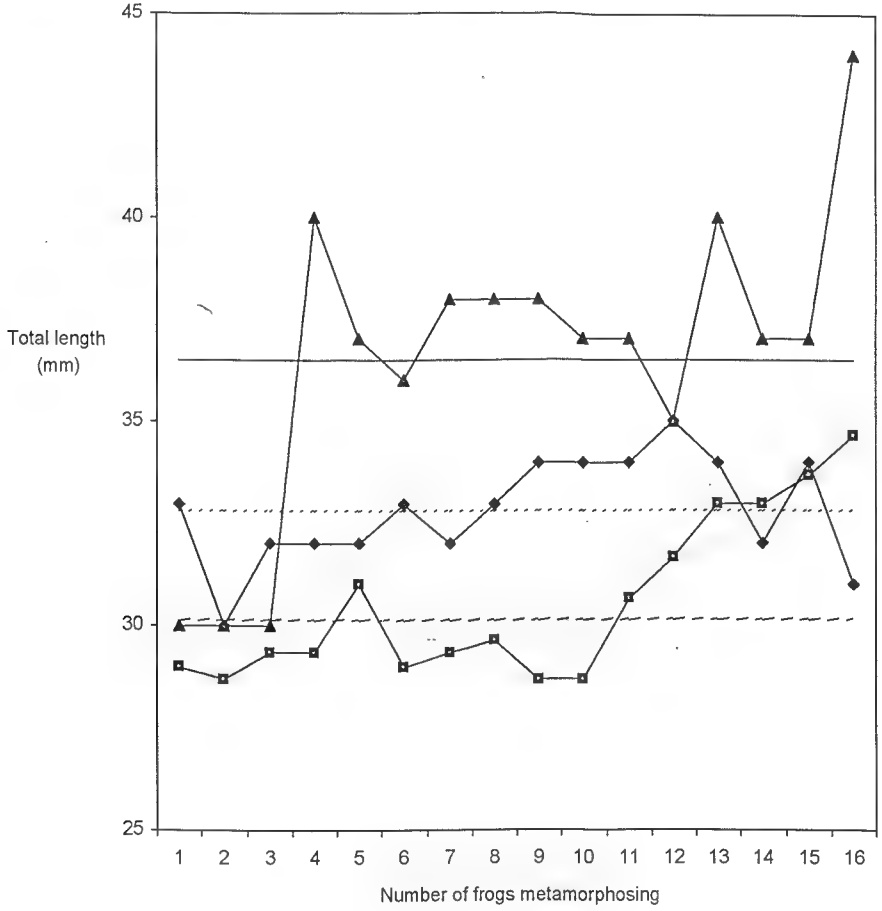


Figure 4. Total length of the first 16 frogs metamorphosing from the five groups of *M. fasciolatus* tadpoles hatched at Melbourne Zoo in 1998.



DISCUSSION

There is very little information in the published literature on frogs in the genus *Mixophyes* in captivity. Indeed, three short reports of *M. fasciolatus* may be the only accounts to date (Marantelli, 1995; Marantelli & White, 1996; Henderson, 1997). The species has not proved difficult to keep in captivity, both at Melbourne Zoo and in other collections (G. Marantelli, pers. comm; R. Porter, pers. comm.). The rearing of young frogs in an off-display area, where they were exposed to the presence of staff, whilst still providing them with appropriate shelter, led to most of those frogs being successful display animals. Many species of frogs are shy by nature and organisations that wish to display frogs must be prepared to allocate the appropriate time

and space to acclimatising frogs to the presence of visitors, if their exhibits are to succeed.

M. fasciolatus regularly spend long periods in the loose substrate of the forest floor (Barker & Grigg, 1977). Hence, palm peat has proven to provide an ideal medium for burrowing and, when wet, retains its moisture content for long periods without regular rewatering. Regular flushing of the substrate assists with the biological breakdown of wastes and sporadic turning over helps to aerate it.

Using data from the Meteorological Bureau to predict approaching cold fronts proved to be a very easy and extremely useful way of ensuring that the necessary stimuli were in place to promote successful breeding, e.g. rain chambers. The latter is an approach that is used for many species of frogs and reptiles to help stimulate breeding (Boyer, 1988; Vosjoli & Mailloux, 1988, 1990).

The observations of egg deposition recorded here accord with those noted by other authors for *M. fasciolatus* in the wild (Barker & Grigg, 1977; Knowles *et al.*, 1997). The only other published account of captive breeding in this species recorded amplexus in December and tadpole development and growth over the following months (Marantelli, 1995). The general timing of reproductive events at Melbourne Zoo would seem to accord with statements by Anstis (2002) that metamorphosis "occurs from January to March. Development from egg to metamorphosis takes 12 months or more". Tadpoles have been also been observed in September in north-east New South Wales (Lemckert, 1996). At the Zoo, the larvae at hatching were larger than that recorded by Anstis (2002) and metamorphosis occurred sooner; it is possible that these differences arose from greater amounts of food and higher temperatures in captivity.

Most of the results from raising *M. fasciolatus* tadpoles under different temperatures suggest that the temperatures used here had no effect on the size at metamorphosis, although it is not known if greater temperature differences would have had an effect. However, those tadpoles raised at the lower water temperatures took longer to metamorphose, presumably caused by the lower temperature slowing down the tadpoles' metabolic rate. The one group of tadpoles that did show an effect was G4, which were raised at the lower temperature range, took longest to metamorphose and were largest at metamorphosis. This latter phenomenon accords with the findings of a number of other researchers (Duellman & Trueb, 1986; G. Marantelli & R. Traher, pers. comm.).

The observation of a direct correlation between larval life span, from stage 42 onwards, and size at metamorphosis accords with the model proposed by Wilbur and Collins (1973), which predicts that, in stable, predictable aquatic environments, which allow for rapid larval growth, then tadpoles would slow their developmental rate and metamorphose at a larger body size. Anuran tadpoles are recognised as being highly phenotypically plastic and able to respond to the effects of food availability, predators, chemicals, parasites, the size of their pond/enclosure, temperature, and even the nutritional input of the female parent via the eggs. They may respond to these factors individually, as well as in various combinations (see Alford, 1999).

There was a clear density effect on tadpole development, with those tadpoles raised at lower densities reaching and completing metamorphosis sooner than those raised under higher densities. This result reflects that found by Sokol (1984) with tadpoles of *Litoria ewingi* and by Cohen & Alford (1993) with tadpoles of *Bufo marinus*.

Metabolic bone disease is commonly encountered in captive amphibians and has two distinct aetiologies: dietary calcium deficiency (absolute or relative, the latter being due to calcium-phosphorous imbalance) and vitamin D deficiency. Hypovitaminosis D is generally thought to result from inadequate ultraviolet light exposure (Townsend & Cole, 1985; Allen & Oftedal, 1989). However, *M. fasciolatus* is a nocturnal burrowing frog and it is unknown whether this species obtains vitamin D from endogenous sources via UV

exposure, or through exogenous sources via the diet.

Nutritional osteodystrophy in sub-adult *M. fasciolatus* is currently being investigated at Melbourne Zoo through a Masters research project. This project aims to investigate the dietary and ultraviolet light requirements of *M. fasciolatus*, as well as the pathogenesis of MBD in amphibians. Results from this study will allow improved recommendations to be made for the captive management of this and other *Mixophyes* species.

This program at Melbourne Zoo with *M. fasciolatus* is part of a national effort by a number of Australian zoos to target frogs in this genus. The other well-established initiative is a collaborative program between Lone Pine Sanctuary (Fig Tree Pocket, Brisbane) and the Queensland Department of Environment & Heritage for *M. fleayi* (P. O'Callaghan, pers. comm.). More recently, Melbourne Zoo has concluded phase one of a project to establish husbandry and captive breeding protocols for the Stuttering Barred Frog, *M. balbus*, in conjunction with the North East New South Wales Threatened Frog Recovery Team and the New South Wales National Parks & Wildlife Service. Many *M. fasciolatus* produced at Melbourne Zoo have been provided to other zoos and private herpetologists to establish public displays and extend the skill base necessary to keep these frogs. Hence, the information gained adds to our knowledge of these frogs and aids conservation initiatives for threatened species in the genus.

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OLD GREEN-THIGHED FROGS?

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The Green-thighed Frog (*Litoria brevipalmata*), is a moderately small (43-47 mm, Barker *et al.*, 1995) ground dwelling, hylid occurring in coastal eastern Australia. The longevity of small ground dwelling frogs is poorly known. The Green-thighed Frog does however, have an unusual reproductive strategy that involves calling for only 1-3 nights a year (if at all) and generally only after heavy rainfall (Lemckert *et al.*, submitted). The breeding sites often dry out within 14-21 days (F.L., pers. obs.) leading to the death of the tadpoles and the failure of the breeding event. Such a strategy suggests that adult Green-thighed Frogs should be relatively long-lived for their size in order to compensate for this unpredictable annual recruitment.

The only information available on the age of this species does not indicate great longevity. Dadds (2000) aged 28 adult Green-thighed Frogs from southern Queensland using skeletochronology and considered 18 individuals to be one year old and the other ten only two years old. He noted that this conclusion was unexpected because of the unpredictable reproductive success of this species.

In January 1999, Green-thighed Frogs bred in an area to the northeast of Bulahdelah, NSW. A number of males (32) were observed calling along a flooded road-side verge and 16 were implanted with 12 mm long microchip "pit-tags" manufactureded by Biomark (Boise, Idaho). The pit-tags were inserted under the skin on the posterior dorsal surface by making an incision in the skin with scissors that was just small enough for the tag to pass through. We did not use the usual needle provided as this required a considerably larger puncture hole than was necessary. The frogs were measured (snout-urostyle length – SUL) and weighed to the nearest one gram (best accuracy available). They were released at the site of capture.

On 15 November 2000, two of three males at the same site had microchips. Both were individuals that had been implanted in 1999. Both had grown and one gained in body mass over the following two years (see Table 1). Both frogs looked in good condition and the pit-tag insertion sites had healed. The presence of the pit-tags was obvious as "bumps" under the skin (see Figure 1), but they did not appear to be of any concern to either frog. As these were adult frogs at the time of initial capture, they were at least one year old and possibly older. Their recapture after almost two years indicates that they were at least three years old in November 2000. Both frogs were released at the site of capture.

On 1 February 2001 one of four males present had a microchip and was one of the two recaptured in November 2000. Its mass and length were the same as those recorded three months previously (Table 1) and the frog was released at the point of capture.

On 15 December 2002, heavy rain fell in the area, but no Green-thighed Frogs were present at the site. However, a chorus of frogs was heard approximately 50 m distant. Subsequent investigation found that this chorus included several calling Green-thighed Frog males, of which three were located. The first of these had a pit tag and was collected for examination and identification. This male Green-thighed Frog was found to be one of the individuals implanted in 1999, but not one of the frogs recaptured in 2000. This

male had also grown, although only 0.9 mm, and gained 1.8 g in body mass (Table 1). This male was also in good condition (reasonably fat) and there was no evidence of any problems associated with the microchips. It was released at the point of capture. Its age at this time would have been no less than five years.

These recaptures demonstrate that individual Green-thighed Frogs can live for at least three years in the wild. Although it has not been established that many do so, its habits predict that at least a number should do so in order to maintain their populations through years when recruitment fails. Recaptures at the site subsequent to the marking event have found at least one in five frogs to be marked and so at least three years old, perhaps suggesting that 20% of the population is three years or older in age. Progressively fewer frogs have been recorded at the breeding site, possibly due to continued disturbance from road maintenance. Hence, the potential for recaptures has continued to decline regardless of whether there are a number of marked frogs still present in the area. The finding of the frog in 2002 at a new site indicates that a wider search to include other nearby flooded areas may lead to additional recaptures.

Why did Dadds (2000) not find such "older" frogs during his skeletochronology study? It appears most likely that the age estimates based on skeletochronology are not accurate in a temperate environment. Ageing frogs this way requires that bone growth occurs at different rates at different times of the year leading to denser bone developing when growth is slower, a situation most likely to occur under cold conditions and/or when food is scarce. The Green-thighed Frog comes from a temperate environment that may not result in any obvious slowing in growth and so not produce a detectable growth ring. If a chipped frog is again recaptured, a toe-clip will be taken and the age attempted to be calculated using skeletochronology. Testing for the presence of rings against a known minimum age should provide a good assessment if annual growth rings are being formed.

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Table 1. Snout-urostyle length (SUL) and body mass of three adult male Green-thighed Frogs at the time of initial capture and at their subsequent recaptures.

Frog	Initial Capture		Second Capture		Days between captures
	SUL (mm)	mass (g)	SUL (mm)	mass (g)	
1	40.2	4	41.4	4	664
2	39.8	2	40.6	4	664
2	40.6	4	40.6	4	78
3	40.2	3	41.1	5	1420

Figure 1. Recaptured adult male Green-thighed Frog, showing pit-tag.

NOTES ON FEEDING CAPTIVE DEATH ADDERS (*ACANTHOPHIS ANTARCTICUS*) , INCLUDING POSTURING BEHAVIOUR IN RESPONSE TO LARGE FOOD ITEMS

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In 2002, I had difficulty in obtaining rodent food for some young captive-bred death adders from the Blue Mountains in New South Wales. As a result the snakes were fed unusually large mice, relative to the size of the snakes. Certain observations made in relation to these and other feedings are reported here.

TRAINING YOUNG SNAKES TO FEEDING ON MICE

Next to nothing would stop these snakes from attempting to feed on mice of any size. It appears that with this species at least, once a snake commences feeding on a prey item, it will continue to do so, regardless of size and even when the item is clearly too large for the snake to digest and/or would cause great discomfort if consumed. This appears to be an instinctive response and not restricted to snakes in captivity, as Hoser (1981) reported a wild-caught death adder that had eaten a water dragon (*Physignathus lesueurii*) too large to digest, and which died when unable to regurgitate the lizard.

This trait can also be used to a keeper's advantage. As a matter of course pre-killed food is the food of choice by many keepers, including myself. Some small death adders are finicky or difficult to feed in captivity, and display a preference for skinks over mice. Young death adders that take skinks can usually be encouraged to "follow-on" to a mouse as they continue to swallow the posterior part of the skink. This can done by placing the head of the mouse into the snake's mouth (with tongs) and the snake continues swallowing this next item. Merely placing the mouse's head immediately adjacent to the snake's mouth and lizard's tail will usually see the snake continue the feeding motion over the mouse.

This trait is one of several means that can be used to switch a difficult snake over to rodents. The next step in switching the snake to mice is usually to tease a hungry snake with a skink before quickly swapping it with a mouse and having the snake strike at and eat the latter item.

Another variant is the use of cotton to tie a mouse to a lizard and feed the pair to a snake. However in this case, one must usually ensure that the mouse's head is taken on the first bite and hence it is not my preferred method.

LOSSES OF YOUNG DEATH ADDERS

Based on conversations with reptile keepers, young death adders held by inexperienced keepers frequently die. Notwithstanding this, there remain many keepers (including myself) who have almost no mortality in their young death adders. Thus some key pointers to success are worth noting.

Death adders like heat and failure to provide enough heat in the cage can give rise to many problems. A temperature gradient is essential to allow the snake to thermoregulate as necessary. Failure to provide sufficient heat is the most common cause of regurgitation and ultimate death in young death adders. This is particularly so if the snake eats unusually large items.

If one is to feed oversized items to a snake it is best not to do so after prolonged fasting. It is better to precede by a day or two with a smaller feed, which appears to get the digestive system into operation at greater speed.

Water is essential to these snakes and a water bowl should be provided. Death adders are quite capable of finding this water and drink-

ing as necessary, contrary to rumours that they are unable to drink and/or only drink when sprayed. Spraying is not necessary for successful husbandry, and although doing this may make the snakes perk up and become more active for a short time, it makes the cages too damp and humid, and this may lead to other problems.

Excluding complications caused by overfeeding and/or lack of sufficient heat for digestion purposes and general health, the most common killer of death adders in captivity is mite infestations or complications arising from them. I use pest strips to kill the mites and have never had pest-strip induced complications, although as with any toxic substance, pest strips should be used with care.

Young snakes should be fed soon after the first slough, avoiding a general weakening of the animal and increased susceptibility to disease. Young snakes need to eat a lot to maintain growth. In the event that a young snake does not take food voluntarily, assist or even force-feeding young snakes may be necessary to avoid loss of condition. These snakes invariably grow normally and without complication and as a rule, will begin to take food as offered within six months.

ANTI-REGURGITATION TACTICS BY DEATH ADDERS

When they have fed, death adders (like other snakes) seek warmth to facilitate digestion. When unusually large items have been consumed, this is even more important. When the food is not digested within a relatively short time, the item may decompose and become toxic leading to regurgitation. This may kill an unhealthy snake, but a healthy snake will usually survive a regurgitation ordeal without any significant long-term damage and be ready to feed again within a few days.

In one case a mouse of similar weight to a young death adder was retained and digested. In three other similar cases, this did not happen, with the mouse being regurgitated. Regurgitation usually occurred from 36 to 84 hours after feeding.

After these incidents, I decided against using such extremely large food relative to body size. However, some large mice (relative to the snakes) were still fed to them and in all cases the snakes engaged in a similar behaviour pattern that was clearly designed to aid digestion and prevent regurgitation.

In addition to seeking out warmth, these snakes drank considerable amounts of water and positioned themselves in an unusual resting position, with the neck region having a strong and distinct kink in it. The kink possibly prevented reflux of digestive fluids to the upper oesophagus and held the food in the lower oesophagus or stomach. This pose was retained until digestion had progressed beyond the stage where the food eaten produced a large fluid filled lump in the mid or even fore-body (the latter reflecting the oversize nature of the food eaten).

I am not aware of any previous reports of this kinking of the neck in response to digestion of oversize food in snakes of any species.

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A SURVEY OF THE REPTILES OF WAGGA WAGGA, NSW

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ABSTRACT

A survey of six sites was undertaken within the boundaries of the Wagga Wagga local government area (LGA) over a 12 month period. Of 35 species identified, four are additions to the previously known fauna. One species of conservation concern, the Southern Death Adder, was recorded at a single site. The sites with the highest biodiversity had good understorey vegetation, while those with the lowest biodiversity had experienced heavy grazing and high public use.

INTRODUCTION

Wagga Wagga is located on the south-west slopes of the Great Dividing Range, 400 km south-west of Sydney in the Riverina district of NSW (35°S, 147°W), at an altitude of around 220 m (Annable, 1995). Wagga Wagga is the largest inland city in NSW with a population of approximately 65,000 residents throughout the LGA. This paper presents the results of a survey of the reptiles of the Wagga Wagga LGA from November 2001 to November 2002 at selected sites.

Much of the landscape in the Wagga Wagga LGA has been affected by land clearing for the purpose of agriculture. Remnant vegetation areas still persist throughout the area, however much of this remnant vegetation is surrounded by heavily grazed or cleared land resulting in the isolation of many flora and fauna communities.

STUDY SITES

The study area comprised six sites throughout the Wagga Wagga LGA. Four of the sites, "Mt Kiaora" (35°06'S 147°32'E), "Ballandry" (35°26'S 147°38'E), Bald Hill (35°03'S 147°21'E) and Plum Pudding (35°14'S 147°19'E) are primarily granite outcrops, including loose rock on rock. Mt Moorong (35°07'S 147°18'E) and Mates Gully (35°15'S 147°41'E), along with the Plum Pudding site, were chosen as they consisted of remnant vegetation of conservation significance in terms of the Threatened Species Act 1995.

Each site was classified using Specht's (1970) system for classification of plant communities. The Mt Moorong and Plum Pudding sites are Forest. The dominant canopy species at Mt Moorong is Yellow Box, *Eucalyptus melliodora*, whilst at Plum Pudding it is Blakely's Red Gum, *Eucalyptus blakelyi*. Mates Gully is Low Forest, dominated by Inland Scribbly Gum, *Eucalyptus rossii*. "Mt Kiaora" and "Ballandry" are grazing land with the remaining trees dominated by White Box, *Eucalyptus albens* and Black Cypress Pine, *Callitris endlicheri*. Bald Hill is also grazing land, but dominated by Kurrajong, *Brachychiton populneus*, and Black Cypress Pine, *Callitris endlicheri*.

The vegetation within each study site is generally not representative of the surrounding area, which consists primarily of cleared agricultural land.

METHODS

Surveys were conducted between 30 November 2001 and 30 November 2002. At each study site, surveys were based around a 2 ha (100 m x 200 m) quadrat. One or two persons surveying for a total search effort of 60 minutes surveyed a 0.5 ha subset of each site for reptiles. These searches were carried out at varying times between 0600 and 2100 hrs. Air temperatures ranged between 6-35°C. Each study site was surveyed for 50 hours over the 12 month period.

The method chosen was random sampling in

which searches were conducted by observing active animals basking or as they foraged. Inactive animals were located by lifting loose rocks, viewing hollow logs, searches of rock crevices, under bark and within leaf litter. Animals were identified by sight at the study site or by digital image at a later time using Cogger (2000) and Swan (1990).

In addition to these standard surveys, food in the form of canned dog food and sardines was provided at feeding stations along two transects within each quadrat. Each transect had four feeding stations placed at 20 m intervals for periods of no longer than two consecutive days on no more than 3 separate occasions. The food was placed on the ground adjacent to a rock or log. Observations of these feeding stations occurred randomly over the two day period. Feeding stations facilitated sightings of larger skinks and monitors which had not been observed during this survey prior to using this method.

RESULTS

This survey located 35 species throughout the six study sites (Table 1). A search of the NSW NPWS Atlas of Wildlife database revealed records for 29 species (Table 2). The survey found six species additional to those listed by Annable (1995), who recorded 38 species (Table 2), with four of these, Bynoe's Prickly Gecko (two sites), Southern Death Adder (one site), Yellow-faced Whip Snake (three sites) and Eastern Tiger Snake (one site), being new records for the Wagga Wagga LGA.

Of the 29 species recorded from the Wagga Wagga LGA in the Atlas of NSW Wildlife database, one (*Ctenotus regius*) is very distant from the previously known distribution (Swan, 1990). It is likely that the record of this species from the Wagga Wagga LGA is in error. With the removal of this species, the total number of reptile species for the LGA is 48 species.

Table 1. Reptiles recorded at each Study Site. MG = Mates Gully, MM = Mt Moorong, MK = "Mt Kiaora", B = "Ballandry", BH = Bald Hill, PP = Plum Pudding. P = Present at site.

Species	Common name	MG	MM	MK	B	BH	PP
Chelidae							
Chelodina longicollis	Eastern Long-necked Tortoise	P					
Gekkonidae							
Christinus marmoratus	Marbled Southern Gecko	P	P	P	P	P	
Diplodactylus intermedius	Southern Spiny-tailed Gecko	P		P	P	P	
Diplodactylus vittatus	Eastern Stone Gecko		P				P
Gehyra variegata	Variegated Gehyra	P		P		P	P
Heteronotia binoei	Bynoe's Prickly Gecko	P	P				
Underwoodisaurus milii	Thick-tailed Gecko			P	P	P	P
Pygopodidae							
Delma inornata	Patternless Delma	P		P			P
Lialis burtonis	Burton's Snake-Lizard	P	P	P			P
Agamidae							
Amphibolurus muricatus	Jacky Lashtail	P					
Pogona barbata	Eastern Bearded Dragon	P	P	P	P	P	P

Varanidae							
Varanus varius	Lace Monitor	P	P	P	P		P
Varanus gouldii	Sand Monitor				P		
Scincidae							
Bassiana platynota	Red-throated Cool Skink	P	P				
Carlia tetradactyla	Southern Rainbow-skink	P	P	P			P
Cryptoblepharus carnabyi	Spiny-palmed Shinning-skink		P				P
Ctenotus robustus	Striped Skink			P	P	P	P
Ctenotus taeniolatus	Copper-tailed Skink	P					P
Egernia cunninghami	Cunningham's Skink				P		P
Egernia striolata	Tree-crevice Skink	P		P	P	P	P
Lampropholis guichenoti	Garden Skink	P	P				P
Lerista bougainvillii	South-eastern Slider	P	P			P	P
Lerista muelleri	Wood Mulch-Slider			P		P	
Menetia greyii	Common Dwarf Skink						P
Morethia boulengeri	Boulenger's Skink	P	P				P
Tiliqua scincoides	Eastern Blue Tongue	P		P	P		
Trachydosaurus rugosus	Shingleback	P	P				
Boidae							
Morelia spilota metcalfei	Inland Carpet Python			P	P		P
Elapidae							
Acanthophis antarcticus	Southern Death Adder	P					
Demansia psammophis	Yellow-faced Whip Snake	P	P				P
Furina diadema	Red-naped Snake	P					
Notechis scutatus	Eastern Tiger Snake			P			
Pseudechis porphyriacus	Red-bellied Black Snake	P	P				P
Pseudonaja textilis	Eastern Brown Snake	P	P	P	P	P	P
Vermicella annulata	Eastern Bandy-bandy	P					P
	SPECIES TOTALS	**25**	**16**	**16**	**12**	**10**	**22**

Table 2. Reptiles recorded at Wagga Wagga, based on this study, Annable (1995) and NPWS Atlas of Wildlife database (2003). P = Present.

Species	Common Name	This study	Annable	NPWS
Chelidae				
Chelodina expansa	Broad shelled Snake-necked Tortoise			P
Chelodina longicollis	Eastern Long-necked Tortoise	P	P	P
Emydura macquarii	Murray Short-necked Tortoise		P	P

Gekkonidae				
Christinus marmoratus	Marbled Southern Gecko	P	P	P
Diplodactylus intermedius	Southern Spiny-tailed Gecko	P	P	P
Diplodactylus vittatus	Eastern Stone Gecko	P	P	
Gehyra variegata	Variegated Gehyra	P	P	
Heteronotia binoei	Bynoe's Prickly Gecko	P		
Underwoodisaurus milii	Thick-tailed Gecko	P	P	
Pygopodidae				
Delma inornata	Patternless Delma	P	P	P
Lialis burtonis	Burton's Snake-lizard	P	P	
Pygopus lepidopodus	Southern Scaly-foot		P	
Agamidae				
Amphibolurus muricatus	Jacky Lashtail	P		P
Amphibolurus nobbi	Nobby			P
Physignathus lesueurii	Eastern Water Dragon		P	
Pogona barbata	Eastern Bearded Dragon	P	P	P
Varanidae				
Varanus gouldii	Sand Monitor	P	P	P
Varanus varius	Lace Monitor	P	P	P
Scincidae				
Bassiana platynota	Red-throated Cool Skink	P	P	
Carlia tetradactyla	Southern Rainbow-skink	P	P	P
Cryptoblepharus carnabyi	Spiny-palmed Shinning Skink	P	P	P
Ctenotus regius				P
Ctenotus robustus	Striped Skink	P	P	P
Ctenotus taeniolatus	Copper-tailed Skink	P	P	P
Egernia cunninghami	Cunningham's Skink	P	P	
Egernia saxatilis	Black Rock Skink			P
Egernia striolata	Tree-crevice Skink	P	P	P
Eulamprus heatwolei	Southern Water Skink			P
Hemiergis decresiensis	Three-toed Earless Skink		P	P
Lampropholis delicata	Grass Skink			P
Lampropholis guichenoti	Garden Skink	P		P
Lerista bougainvillii	South-eastern Slider	P	P	
Lerista muelleri	Wood Mulch-Slider	P	P	
Menetia greyii	Common Dwarf Skink	P	P	
Morethia boulengeri	Boulenger's Skink	P	P	P
Tiliqua scincoides	Eastern Blue Tongue	P	P	P
Trachydosaurus rugosus	Shingleback	P	P	

Typhlopidae				
Ramphotyphlops bituberculatus	Prong-snouted Blind Snake		P	P
Ramphotyphlops nigrescens	Blackish Blind Snake		P	
Ramphotyphlops proximus	Proximus Blind Snake		P	P
Boidae				
Morelia spilota metcalfei	Inland Carpet Python	P	P	P
Elapidae				
Acanthophis antarcticus	Southern Death Adder	P		
Demansia psammophis	Yellow-faced Whip Snake	P		
Furina diadema	Red-naped Snake	P	P	
Notechis scutatus	Eastern Tiger Snake	P		
Pseudechis porphyriacus	Red-bellied Black Snake	P	P	P
Pseudonaja textilis	Eastern Brown Snake	P	P	P
Suta dwyeri	Variable Black-backed Snake		P	P
Vermicella annulata	Eastern Bandy-Bandy	P	P	
	SPECIES TOTAL	**35**	**38**	**29**

DISCUSSION

The greater number of species, 25 and 22 respectively, were found at Mates Gully and Plum Pudding. Both of these sites, along with Mt Moorong, have considerable remnant vegetation and their flora is considered to be of conservation significance under the Threatened Species Act, 1995. Good understorey vegetation was present at the Mates Gully and Plum Pudding sites only (Table 3), and this may be an important feature in maintaining the high species diversity at these two sites. The absence of understorey vegetation at the remaining four sites is attributable to a history of heavy grazing and high public use.

Table 3. Overview of variables at each study site. MG = Mates Gully, MM = Mt Moorong, MK = "Mt Kiaora", B = "Ballandry", BH = Bald Hill, PP = Plum Pudding.

Study Site	Granite Outcrops	Remnant Vegetation	Good Understorey	History of heavy grazing	High Public Use	No.of sp. present
MG		X	X			25
MM		X		X	X	16
MK	X			X		16
B	X			X		12
BH	X			X		10
PP	X	X	X			22

The Mt Moorong site was a public grazing reserve until recent years. Heavy grazing occurred and although activities such as four wheel driving and motocross are now prohibited, the reserve is still under high public use. As a result, the understorey vegetation at Mt Moorong is poor, despite its conservation significance. The previous land uses of this reserve and the ongoing recreational use by the general public may have led to a reduction on the number of reptile species present. It is difficult to determine the effects of this usage, with very little reptile survey work carried out in the past. Further investigation on the effects of these impacts would be warranted.

The "Mt Kiaora", "Ballandry" and Bald Hill sites also have fewer reptile species present than Mates Gully and Plum Pudding. This may be attributed to the absence of any significant native vegetation, and in particular, a good understorey. In the absence of understory vegetation, the granite outcrops present at the three former sites may provide important habitat for species associated with rocky areas and enhance the species diversity. Without these rocky areas, these three sites would be expected to have far fewer numbers of species present.

One species of conservation significance is *Acanthophis antarcticus*. There have been very few recent sightings of the Southern Death Adder west of the Great Dividing Range (Sadlier *et al.*, 1996). The Mates Gully site, where one individual was sighted, warrants further investigation to ascertain the status of this species in the locality.

The provision of feeding stations used throughout the study provided additional data for species that had not previously been identified but were expected within the study area. Cunningham's Skink, Sand Monitor, Eastern Blue Tongue and Shingleback were all sighted at feeding stations only. These larger species may have been affected by the extended period of low rainfall that has occurred in the study area over the last two years.

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OBSERVATION ON SHALLOW WATER USE BY A SEA SNAKE (*DISTEIRA KINGII*)

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INTRODUCTION

The distribution of hydrophiine sea snakes has been looked at in great detail, based mainly on incidental captures by trawlers. Data collected by this method are not usually geographically accurate, and may be confounded by trawl type. In fish trawls, hydrophiines constitute 60% of the total catch (Ward, 1996a) while in prawn trawls, they constitute 80% of the total catch in northern Australian waters (Ward, 1996b). Most of this work suggests that depth plays an important role in sea snake distribution (Redfield *et al.*, 1978), including *Enhydrina schistosa, Emydocephalus annulatus, Disteira kingii, Aipysurus* spp. and many *Hydrophis* (Heatwole, 1999). The depths at which sea snakes occur may relate to their diet and basic shape. For example, species like *Emydocephalus annulatus*, which inhabits shallow waters, primarily eat fish eggs that they extract from reef crevices, while *Hydrophis melanocephalus* primarily eats deep water eels (McCosker, 1975).

Disteira kingii is a microcephalic sea snake found from northwestern Australia to the east coast of Queensland (Cogger, 1975; Heatwole, 1999), and adjacent parts of Papua New Guinea (O'Shea, 1996). Most records of *D. kingii* are from deeper waters (Redfield *et al.*, 1978; Wassenberg *et al.*, 1994; O'Shea, 1996; Ward, 1996a), including records from the Townsville area (Dunson, 1975).

OBSERVATION

On 11 March 2000 at 1530hrs, an adult *D. kingii* (snout-vent length 970 mm, total length 1065 mm, mass 270 g, sex not determined) was caught off the coast of Townsville by the trawler *James Kirby*. The snake was caught in a trawl net in 2 m of water, as indicated by the depth finder. This area has a sandy bottom and no other structures.

DISCUSSION

Although most previous records of *D. kingii* are from deeper waters (5-20 m, Wassenberg *et al.*, 1994; 7-22 m, O'Shea, 1996), a few have been recorded from shallower waters (0-5 m) in the Gulf of Carpentaria (Wassenberg *et al.*, 1994). Porter *et al.* (1997), working in the Hey-Embley and Mission River estuaries near Weipa, Gulf of Carpentaria, collected three *D. kingii*, all juveniles. Although water depth was not reported for these captures, they reported captures of *Enhydrina schistosa* from the same area in water up to 8.5 m deep, and noted that a high proportion of captures of several sea snake species in these estuarine environments were of juvenile snakes. Hence, they suggested that for these species, estuarine environments may serve as breeding grounds or nurseries. Although sample sizes remain small, our capture of an adult *D. kingii* in a non-estuarine shallow water situation does not support the view that there is a size-related preference for water depth alone in this species.

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INCUBATION OF LACE MONITOR (*VARANUS VARIUS*) EGGS

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The lace monitor (*Varanus varius*) is one of Australia's largest lizards with large males sometimes exceeding 2 m in length (Hoser, 1989). The species is a common captive in Australia, but is still not commonly bred. Lace monitors are usually housed communally in large outdoor cages and even when breeding does occur, cage cohabitants often feed on eggs laid by other lizards before keepers can recover them for external incubation (Hoser, 1998).

Published reproductive data, including both captive breeding and incubation of eggs from wild-caught gravid females or nests, includes Fleay (1950), Peters (1970), Horn (1980, 1991), Bredl and Schwaner (1985), Markwell (1985), Horn and Visser (1991) and Boylan (1995). None of these sources gave information on incubation temperatures and its effects on hatching rates and times, save for Markwell (1985) who said temperature was "variable" and Horn (1991) and Horn and Visser (1991) who said that their eggs hatched after about 235 days when incubated at a constant 29°C.

Published results for other Australian varanid species as cited in Greer (1989) indicate that the eggs of most species are successfully incubated in captivity at about 29-30°C.

Provided here are some recent breeding results and data from keepers in the Melbourne area. In all cases, the monitors were housed in large outdoor "pits" and thus were subjected to local seasonal climate changes and variations.

Breeder One

This keeper had eggs laid on several occasions, but invariably they were eaten by other monitors in the same cage before they could be recovered. However on one occasion in early 2000 he managed to retrieve and hatch three eggs. The parents were both of the common dark colour phase (Hoser, 1989: Pl. 304). Notwithstanding this, one of three hatchlings was a broad-banded (Bell's) form of lace monitor (Hoser, 1989: Pl. 305). The other two hatchlings were the more common dark form.

The eggs were incubated in a thermostatically controlled incubator at 30°C, with a maximum temperature variation of ± 1°C and took just under nine months to hatch. The incubation medium used was coarse grade vermiculite at about 50-45:50-55 dry vermiculite to water (by weight). The incubator was a large sealed wooden box fitted with light bulbs at the top, similar to that described by Barnett (1981, 1998). The eggs were held separated from one another in a sealed plastic tub almost completely covered in the vermiculite. This container was briefly opened once a week to allow air interchange.

It was noted that if the eggs appeared indented on the top, they could be rehydrated within a few seconds by fanning them with the container lid.

Breeder Two

This keeper hatched lace monitor eggs on two occasions. These were incubated in an incubator made out of a converted fridge. Light bulbs were attached to the floor. The top and bottom of the fridge had two large computer fans facing one another to circulate the air. A probe thermostat in the centre of the fridge maintained the temperature at an even temperature. The door of the fridge had a small viewing window in it. The eggs in this incubator were also placed in sealed plastic containers where they were buried singly in coarse grade vermiculite at a 50:50 water to

vermiculite ratio. The containers were briefly opened once a week to allow fresh air inside, but otherwise not interfered with (also see case "B" below).

Case A

Seven eggs were laid on 20 December 2000 and six were eaten by another lace monitor before the keeper managed to recover the remaining egg. It was incubated at 29.4°C and hatched on 20 September 2001, 274 days (nine months) later.

Case B

This resulted from a Murray River, Victoria male mating with a Gippsland, Victoria female. Five eggs were laid on 28 January 2002. They measured 67 mm x 40 mm (straight line measurements). These eggs were incubated at 30.5°C. Shortly into incubation, it was noticed that all the eggs had dried and shrivelled up, due to the plastic container containing the eggs not being sealed and moisture leaking out. The eggs were sprayed in order to try to rehydrate them. Three died at about this time and were discarded, while two recovered and were incubated full-term. For the rest of the incubation period the eggs were sprayed every third day to prevent them drying out. The incubation container was not changed. These eggs hatched on 4 November (280 days) and 18 November 2002 (294 days). The hatchlings measured 150 mm snout-vent length, 370 mm total length and 130 mm snout-vent length, 340 mm total length.

DISCUSSION

The first case demonstrates that the broad-banded colour phase of *Varanus varius* is not a different taxon, and that the colouration results merely from the interaction of one or more recessive genes.

Due to the long incubation period of lace monitor eggs, it is imperative that proper incubation conditions be maintained for the duration of incubation. Potential breeders of this species should be aware of these preconditions for success and plan accordingly. Keepers should also be mindful of the propensity for adults to eat freshly laid eggs and consider isolating females at laying time.

For the second breeder, in theory clutch B should have hatched faster than clutch A, due to the higher incubation temperature. However it appears that the dehydration of the eggs in the early part of the process may have caused the incubation process to have stalled or slowed during this period, in much the same way illness may stall growth of young animals, causing the longer incubation period. Temperature may not be the only determinant of incubation time for reptile eggs.

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A MODIFIED COTTON SPOOL TRACKING DEVICE FOR INVESTIGATING MOVEMENT OF REPTILES

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ABSTRACT

Attachment of a device that provides a trace of an animal's movements has played a role in movement studies for decades. However, past spooling devices tended to be bulky and relatively heavy. We present a modification of the traditional tracking device that greatly reduces its weight, is quick and easy to produce, cost-effective to use and has been successfully trialled on both turtles and dragons.

INTRODUCTION

Spool tracking devices have been used in reptile movement investigations (eg. Strang, 1983; Stott, 1987; Hailey, 1989) since 1927 when Breder introduced the technique to study turtles. Stott (1987) illustrated that such a device provided more precise tracing of animal movement than radio tracking. He modified Miles' (1981) tool to study movement of the Eastern Longneck Turtle *Chelodina longicollis*. As part of our studies on home range and movement of reptiles we, in turn, have modified the cotton-spooling technique of Stott (1987) and Hailey (1989) to follow the movement of both *C. longicollis* (carapace length 62 – 210 mm) and the forest dragon *Hypsilurus spinipes* (snout-vent length 110 mm).

The tracking spool device consisted of a cotton bobbin (thread drawn from the centre), covered with heat-shrink plastic. We found it desirable to make slight modification to the device, dependant upon the size of the species and whether we were attaching it to the shell of the turtles or the tail of the dragons. Cotton spools used for turtles were slightly larger (white nylon bobbins Penguin Threads Pty Ltd #1572-105, approximately 250 m) than for dragons (#1072-105, approximately 225 m).

To construct the *H. spinipes* device, we placed a bobbin, approximately 32 mm long, into a length of cylindrical black heat-shrink plastic (Heatshrink shields™, Pyrotenox, Sydney, 32 mm wide when flat), cut to approximately 35 mm long. These were placed in a domestic oven at 100°C for approximately 30 minutes, or until the plastic had shrunk firmly around the bobbin. They were then removed from the heat, allowed to cool and excess plastic was trimmed to the size of the bobbin.

To attach to the animal, we first ensured that the appropriate section of the upper tail was dry and then the device was attached by binding it firmly with 3M medical tape, ensuring that it was placed just sufficiently laterally not to impede movement of the legs while the trailing edge of the spool was facing posteri-

orly. After tape was blackened with a marking pen, the dragon was then released at point of capture with the thread tied off to nearby vegetation.

The spools used for *C. longicollis* were larger (36 mm long x 16 mm diameter) and the heat shrink plastic was proportionally larger in diameter (ie. 35 mm wide when flattened). The plastic was cut into approximately 70 mm lengths. The bottom half of each length of plastic tube was clamped into a bench vice and the spool was lowered into the upper half. Heat was played around the top of the tube from a distance of approximately 20 to 30 cm, using hot air from an air gun (Black and Decker™ BD 1602/H3A, 1600 Watt, 300 - 560°C), until the tubing had shrunk firmly onto the bobbin. When the tracking device was removed from the vice the tube had a section in which the bobbin was firmly embedded in the plastic sleeve and a flattened 'tail' that provided an attachment point to the animal. Each spool was attached to the posterior segment of the carapace, such that it provided minimum opportunity to impede movement within the environment. The heat-shrunk end of the device faced towards the posterior of the turtle so that the thread was free to trail behind the animal.

To attach the device to *C. longicollis*, the appropriate section of the carapace was cleaned and dried with paper towel and any algal growth removed with a stiff plastic bristled brush. The tracking device was then attached to the turtle by the flattened section, using glue (Selly Araldite® 5 minute epoxy adhesive), and black plaster (Stylus 48 mm wide) was used for reinforcement. After attachment, turtles were kept for about five minutes to allow the glue to dry. Finally, the end of the thread was tied off to vegetation at the site of capture and the animal was released.

DISCUSSION

Our innovation is superior to the prototypes because it is much lighter in weight. For example, Stott's (1987) spool weighed between 46.9 and 51.7 g (mean 49.4 g) while Hailey's (1989) device weighed about 60 g. In contrast, our spool weighed between 6.0 and 6.4 g (mean 6.2 g). It was cheap, quick and easy to assemble and was less bulky than the prototypes. For example, Stott's (1987) spool required a 'king' spool, plastic syringe case, a dowel stopper and wooden handle, while Hailey's (1989) device consisted of a cotton spool, plastic cement, alluvium sheets and a plastic bottle. They were, therefore, both more time consuming to construct and the finished product was much bulkier.

The spool tracking device proved satisfactory for tracking *H. spinipes* but there was an impediment with their use for *C. longicollis*. The amount of thread available was sometimes insufficient for the distance moved by turtles although Gerry Swan (pers. comm.) observed that joining two spools together to increase the thread length was useful for following goannas. The alternative is to use a larger size bobbin. However, Penguin do not make large bobbins that release thread from the centre and we have been unable to locate an alternative supplier.

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COMMUNAL NESTING IN THE TROPICAL SKINK, *LYGISAURUS LAEVIS* (OUDEMANS 1894)

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The incidence of communal nesting has been well documented in various skink taxa restricted to cool, temperate south-eastern Australia (Pengilley, 1972; Rounsevell, 1978; Greer, 1989; Shine & Harlow, 1996). However, less well documented has been the incidence of communal nesting in skinks from northern and tropical regions of Australia (Greer, 1989). Indeed, the low number of documented examples of communal nesting in lizards from these regions seems counter intuitive given that the majority of Australia's reptile biodiversity occurs in northern and tropical Australia (Cogger & Heatwole, 1981). Moreover, all current documented cases of communal nesting in Australian lizard species have been for members of the *Eugongylus* group of lygosomine skinks (Greer, 1989), a group that is distributed widely throughout tropical Australia (Cogger & Heatwole, 1981). In this note we report on the incidence of communal nesting in the small tropical skink, *Lygisaurus laevis*.

Late in the 2001 wet season (i.e., late March-early April) earth moving activity in a coastal *Melaleuca* forest (15 km north of the city of Cairns, Queensland) exposed a large nest of communally laid lizard eggs. The top portion of the nest had a covering of *Melaleuca* leaves, with the majority of the eggs positioned under a series of small rocks (10-40 mm diameter) and logs (10-30 mm diameter) (Fig. 1). The nest site was shaded for the majority of the day by the forest canopy, but was exposed to direct sunlight late in the afternoon (>4.30 pm EST). The eggs ranged in depth from 70-100 mm below a covering of leaf litter on the surface. As a result of the impending construction on the site, and to ensure that hatchlings within the eggs would be accurately identified, we removed all eggs from the nest. A total of forty-five eggs were located in the nest. Approximately half of the eggs were transferred to either a 1 L glass jar or an opaque 0.75 L plastic container each half filled with soil from the nest. Eggs were removed and placed in the same orientation as they had been laid. Each egg was buried in the soil to a depth of 3-8mm and the two containers placed in a room with a mean temperature of 25°C (range 20-28°C) for incubation.

All of the artificially incubated eggs hatched within three weeks of being removed from the nest. All hatchlings were identified as the species *L. laevis*, a small, litter dwelling scincid (maximum snout-vent length 37 mm), with a tropical distribution (Ingram & Covacevich, 1988). Five individuals that died within three days of hatching were placed in alcohol as voucher specimens, to be lodged with the Queensland Museum. All other individuals were released near to the nest site. Like all members of the genus *Carlia* and *Lygisaurus*, this species produces a clutch consisting of two eggs (Greer, 1989). Therefore, we estimate that the nest contained the clutches produced by at least 23 individual female skinks.

In the tropics, communal nesting has been documented for the closely related species *C. rhomboidalis* (as *Leiolopisma rhomboidalis*; Wilhoft, 1963) in northern Australia, and in the skink *Cryptoblepharus poecilopleurus* in Hawaii (McGregor, 1940; Greer, 1989). The nests of both of these species contained more than 70 eggs, which are likely to contain the clutches of at least 35 individual female skinks (Greer, 1989), indicating that communal nests in tropical regions can be quite large. The apparent paucity of communal egg laying in northern and tropical *Eugongylus* skink species may represent a real biological trend, or alternately, may simply represent inadequate reporting of such behaviour. Indeed, this is not surprising given that the majority of institutions and research has been conducted in Australia's temperate regions. However, the past decade has seen a

substantial increase in the amount of research conducted on reptiles in the northern Australian wet-dry tropics (e.g., Shine *et al.*, 1997; Madsen & Shine, 2000; Webb *et al.*, 2001; Brown & Shine, 2001). Thus, it is anticipated that with this increase in research more taxa may be identified as communally nesting species.

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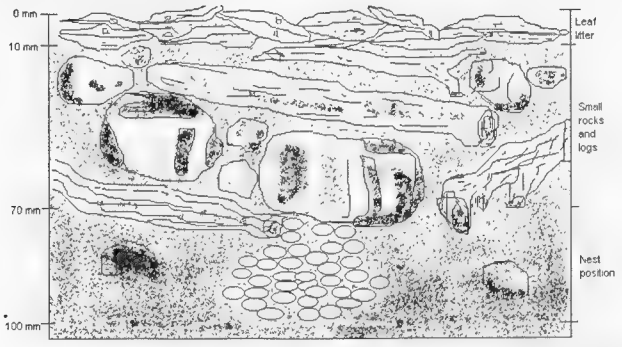
Figure 1. Position and depth of eggs and cover objects of communal *Lygisaurus laevis* nest.



EASTERN WATER DRAGON (*PHYSIGNATHUS LESUEURII*): ADAPTATION TO CHANGE IN LANDSCAPE

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Encroaching suburban development on the Australian landscape is normally associated with a decline in reptile species. Some exceptions exist, usually among the skinks (Greer, 1989; Shea *et al.*, 2002) and geckos (Wilson & Czechura, 1995), while the Eastern Brown Snake, *Pseudonaja textilis*, has also been reported to benefit from agricultural and urban development (Shine, 1989). The following observation records success of the Eastern Water Dragon (*Physignathus lesueurii*) in adapting to man-made changes in environment on the north coast of New South Wales.

OBSERVATIONS

At Banora Point (28°12'S 153°33'E), near Tweed Heads, NSW, there has been considerable development over the past decade of what was once farming land. A golf course at Banora Point has a club building located on the edge of a large freshwater lake. Although the golf course was originally marshland, the area has been drained and is now heavily landscaped. The surrounding hills, once cattle farming pasture, are now covered with houses.

One feature, of not only the golf club but also the whole area, is the frequency of large basalt boulders used to support landscaping features such as terracing. Around the borders of the freshwater lake at the golf course, these basalt boulders now provide a diverse array of new home sites to Eastern Water Dragons. I have observed the lizard population at this location over the last 8 years (1996-2002), usually during the months of April-May. During this period, the population size appears to have remained relatively large, and consists of lizards of all sizes. In some areas the number of lizards per square metre is extremely high with individuals on almost every second rock. The population density seems very much higher than that observed in creeks in the nearby National Parks.

At another location in the Tweed area, the use of large boulders in landscaping has apparently assisted Eastern Water Dragons to colonise or remain in areas surrounded by urban development. Along the lower Tweed River (29°11'S 153°33'E), which is tidal salt water, there are man-made banks where large boulders have been used to contain the river. Over the same period that I observed the dragons at the golf course, this location has also supported a population of Eastern Water Dragons despite being adjacent to heavy urban development and frequent pedestrian traffic.

My final observation reports the utilisation of dwellings for shelter by this species. On the south side of Banora Point Golf Course there was once a canal cut into the landscape to drain water from the nearby hills. This canal supported a small population of Eastern Water Dragons. Over the last eight years I observed this open canal as it was converted to a covered pipe and the surrounding open area was covered by houses. The dragon population in this canal appears to have moved to the basalt boulders used at nearby dwellings as retaining walls. This is notwithstanding the fact that these houses are now approximately 500 m from the nearest open freshwater and that numerous man-made obstacles block access to this water.

At one of these houses, Eastern Water Dragons take advantage of the enclosed foundations under the house (Fig. 1), sheltering on the joists at night in both summer and winter (Fig. 2). They enter this area through narrow ventilation gaps in the brick wall (Figs. 3-4). This has occurred for the last two years,

although the narrow dimensions of the entry point would seem to prevent the lizards from accessing the shelter once they become fully grown.

My observations indicate that in this area at least, Eastern Water Dragons have adjusted to urban development. In contrast, the other large dragon species in the Tweed area, the Bearded Dragon (*Pogona barbata*), seems to have declined.

DISCUSSION

It is curious that Eastern Water Dragons in this area appear to live in relatively high densities where man-made shelter is provided, while their numbers in the National Park habitats seem at such lower densities. Perhaps the urban environments provides a greater supply of food or the type of rock landscaping provides an abundance of suitable shelters that are not available in a natural landscape.

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Figure 1. Juvenile water dragon on house foundations.

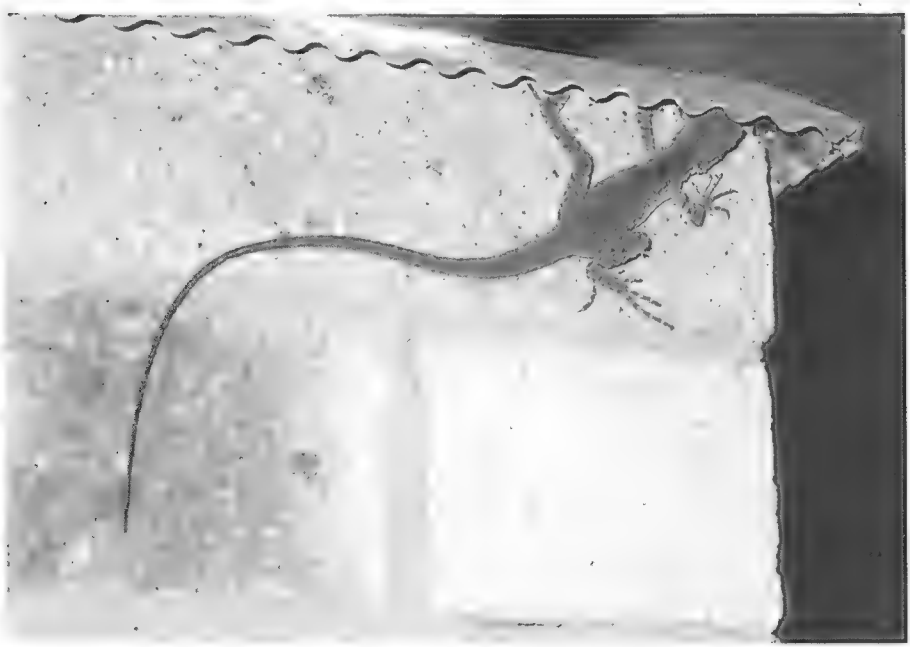

Figure 2. Water dragon sleeping on timber joist below house.

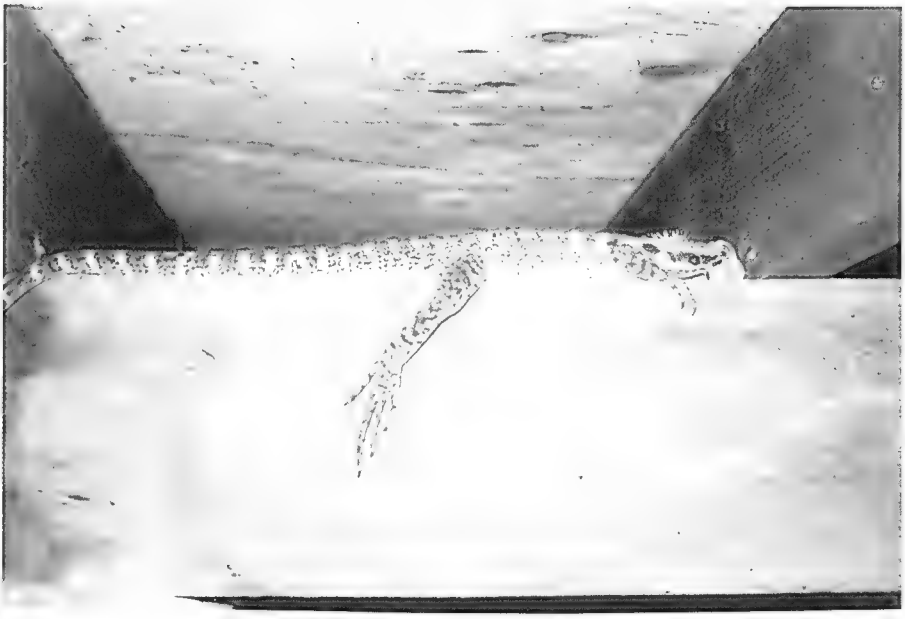

Figure 3. Water dragon accessing house foundations via ventilation points.

Figure 4. Water dragon accessing house foundations via ventilation points (closer view).

AN OBSERVATION OF FEEDING BY THE REGAL SKINK *CTENOTUS REGIUS* STORR, 1971

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The scincid genus *Ctenotus* is the largest reptile genus in Australia. It comprises at least 94 species of small to moderately-sized, terrestrial, diurnal species, most of which are distributed across inland desert environments (Cogger, 2000). Most *Ctenotus* species are active predators and agile climbers that are often observed foraging at relatively high temperatures (Greer, 1989). Dietary analysis for several *Ctenotus* species has revealed them to be opportunistic predators, generally of invertebrates, with some minor intake of small vertebrates and plant material (Pianka, 1969; Archer *et al.*, 1990; Brown, 1991; James, 1991; Bedford, 1992; Twigg *et al.*, 1996).

This note presents an observation of herbivory by an adult Regal Skink *Ctenotus regius* near Lake Menindee in south-western New South Wales (see Brown *et al.*, 2001 for habitat descriptions of the region). At 10 am on Monday 29th January 2001, during a standardised herpetofaunal survey on the southern margin of Lake Menindee near Cawndilla Creek (1:100,000 Menindee map 7333, 32°23'24"S, 142°16'50"E), the lizard was observed to emerge from the base of an apparent Bluebush and proceed to a position about 1 m from the shrub where it remained basking for several minutes. It then returned to the Bluebush to bite off and ingest several small fleshy leaves, before again taking up a basking position away from the shrub. It repeated this sequence several times over the course of 30 minutes, until the observer moved on.

Subsequent identification of the Bluebush revealed that it was most likely an intergeneric hybrid, the parent species of which were probably Ruby Saltbush *Enchylaena tomentosa* and a Bluebush *Maireana* sp. (D. Cameron pers. comm.).

Similar feeding behaviour was observed for *C. uber orientalis* (now *C. orientalis*) in a desert environment of central South Australia, during which an individual climbed several small fruiting Ruby Saltbushes in order to forage on red berries (Bedford, 1992).

ACKNOWLEDGMENTS

I thank Jane Dickens and David Cameron (both Arthur Rylah Institute for Environmental Research) for botanical identification and information, and Graeme Newell (also ARIER) for casting a discerning eye over the manuscript.

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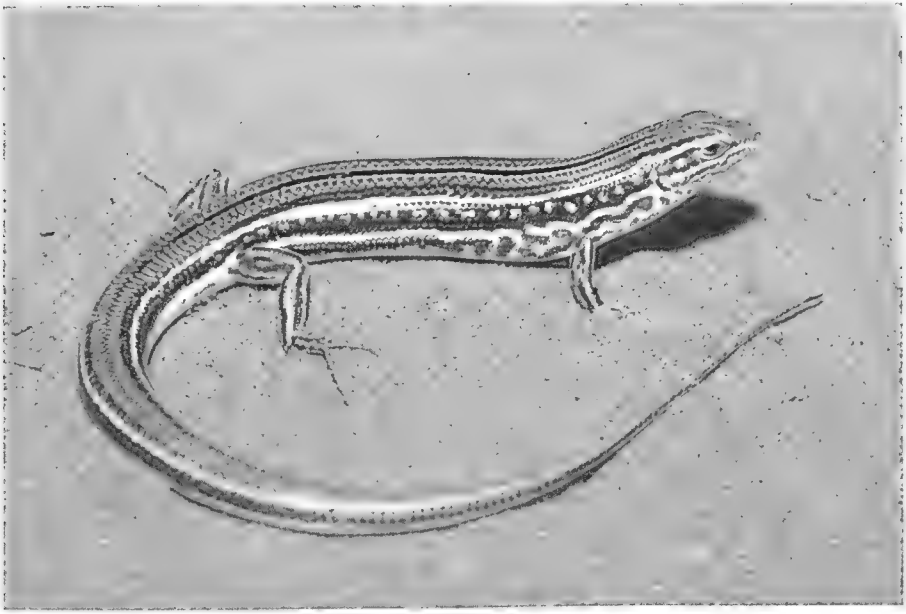
Figure 1. Adult Regal Skink *Ctenotus regius*, from Menindee Lakes, New South Wales.



TYPE LOCALITY OF THE PIG-NOSED TURTLE (*CARETTOCHELYS INSCULPTA* RAMSAY)

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The Pig-Nosed Turtle, *Carettochelys insculpta*, is the only living member of the family Carettochelyidae, and has been the subject of much interest since its description (Georges & Rose, 1993), including early controversy, in the absence of cervical vertebrae from the type specimen, as to whether the family belonged to the suborder Cryptodira or Pleurodira. The holotype, a stuffed and mounted dry specimen, is in the Australian Museum (R3677; Shea & Sadlier, 1999).

Other than "Fly River, New Guinea" in the title, there is no other indication in the type description of the species by the Curator of the Australian Museum, E.P. Ramsay (Ramsay, 1886) as to where it came from. No collector nor date of capture is given. Subsequent descriptions (Waite, 1905; Cogger *et al.*, 1983; Georges & Rose, 1993; Cann, 1998; Georges *et al.*, 2000) narrow the type locality to the Strickland River. It was on the 1885 New Guinea Expedition (Everill, 1888), sponsored by the Geographical Society of Australasia in Sydney, that both the Strickland River was found and named and the Pig-Nosed Turtle was found.

While researching and writing a narrative on the New Guinea Expedition (Mackay, in prep.), I examined some of the diaries of the members of the expedition. This led me to find the facts of the capture, date of capture and the collector of the turtle. There were twelve scientists/technicians, eleven Malay labourers and one Cingalese (Sri Lankan) cook on the expedition. Each of the scientists/technicians kept a diary. Only five diaries have been found and these are in the Mitchell Library, Sydney. One other diary, a transcription of W.W. Froggatt's diary, is in the Papua New Guinea Special Collections in the Library of the University of Papua New Guinea (Froggatt, 1936). W.W. Froggatt's transcription of his own diary gives the full facts. Froggatt was zoological collector and entomologist on the expedition.

On 27 August, 1885, the expedition ship, *Bonito*, carrying the scientists and crew, became trapped high and dry, wedged into the bank of the Strickland River at what is now known and marked on maps as Observatory Bend (*ca.* 6°38'30"S 142°06'35"W, see TOMU sheet 7384, Papua New Guinea topographic map 1:100,000 series). On 16 September, 1885, half of the party left the stranded ship in the whaleboat to try to reach the mountains, one of the aims of the expedition. On 18 September, Froggatt records in his diary that "Mr Shaw caught a turtle." This was a short while before they set up a camp for the night. They called this camp Turtle Camp. On 19 September, Froggatt records ".. skinned the turtle and found her full of eggs which were very good eating." On Sunday 20 September, Froggatt records "Day of rest. So finished skinning the turtle, dried, and put him away."

The map reference for Turtle Camp is *ca.* 6°25'30"S 142°04'30"W (see NOMAD sheet 7385, Papua New Guinea topographic map 1:100,000 series).

Therefore the turtle was collected by James H. Shaw, photographer and explorer on the expedition. It was preserved for posterity by W.W. Froggatt. The date of capture was 18 September 1885 and the nearest locality we can get for the type specimen is Turtle Camp, as above.

In Waite (1905) there is an account of "*information kindly supplied* (my italics) by Mr. Walter W. Froggatt, F.L.S., Government Entomologist for New South Wales" (see also Cann, 1998) in which Froggatt states that the type "... was one of two specimens obtained

in the Strickland River ..." and "... as we towed the boat along the two turtles ran off the sand banks into shallow water and were caught. We ate the contents of both: a large number of eggs were found inside them." Also Froggatt states "This was about the middle of October 1885. Jas. H. Shaw and I caught the type one evening, and I skinned and cleaned it."

It seems Froggatt supplied information from memory to Waite which is in conflict with the diary transcription and that the full account of the capture, locality and date given in the diary transcription should be the accepted truth. Note that only one turtle was captured according to the diary transcript and that the date of capture was 18 September and not "about the middle of October." Other diaries do not give an account of the capture of the turtle. They do concur as to the date they were at Turtle Camp. Note also that the various spellings of *Carettochelys* in early accounts, noted by Cogger *et al.* (1983) and Cann (1998: 225), are corrected in an errata slip at the beginning of the volume of the Proceedings of the Linnean Society of New South Wales that contains the description.

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NOTES ON THE REPRODUCTION OF THE WEASEL SKINK *SAPROSCINCUS MUSTELINUS* (O'SHAUGHNESSY)

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INTRODUCTION

The Weasel Skink *Saproscincus mustelinus* is a small skink common throughout the wet sclerophyll forests, temperate rainforests, woodlands and heathlands of eastern New South Wales and south-eastern Victoria (Wilson & Knowles, 1992). Predominantly crepuscular, and occasionally diurnal in habits, it shelters in logs, beneath leaf-litter and under stones and surface debris, being a common inhabitant of suburban gardens (Wilson & Knowles, 1992; Cogger, 2000).

Although common throughout its range (Stanger *et al.*, 1998), little is documented with regard to the life history of this species. It is known that many species of *Saproscincus*, including the Weasel Skink, are communal egg-layers (German, 1986; Ehmann, 1992; Wilson & Knowles, 1992). It has been recorded that females lay between two and seven eggs per clutch (Greer, 1989; Ehmann, 1992), but only limited information has been recorded on the size and growth of hatchling Weasel Skinks (German, 1986; Banks, 1992).

This study adds further information on egg and hatchling size, as well as documenting the incubation period. I also describe the husbandry techniques used for this species.

METHODS

Four gravid adult Weasel Skinks were collected from within the grounds at Healesville Sanctuary, Victoria (38°20'S 145°30'E) during November and December 1999. This provided an opportunity to record data on the clutch sizes and incubation period, and the subsequent weights and measurements of the hatchlings.

The females' initial weights and morphological measurements (snout-vent (S-V) length and total length) were recorded; they were then housed separately in small click-clack containers measuring 240 mm long x 170 mm wide x 80 mm high. These were half filled with moistened peat moss, with a small water bowl and a piece of bark added for shelter. Each container had a perforated lid, which allowed airflow but prevented the skinks from escaping.

Once females laid their clutches, all eggs were removed from the containers, weighed on an electronic balance scale to 0.1 g accuracy, and their dimensions measured with vernier callipers to 0.1 mm. Clutches from females 1 and 2 were each set up in a small container two-thirds filled with moistened peat moss (moistened at a ratio of 50% water to 50% peat moss). The containers were sealed with a plastic lid to prevent evaporation, and were kept in the Reptile House at room temperature (~26°C). The clutches from females 3 and 4 were placed into containers two-thirds filled with vermiculite (moistened at a ratio of 50% water to 50% vermiculite). These containers were also sealed with a plastic lid and placed into an incubator that was thermostatically controlled at 28°C. After laying their eggs the females were weighed before being released back into the sanctuary grounds in the area where they were originally found.

Hatchlings were weighed on an electronic balance scale to 0.1 g accuracy and measured with a clear plastic ruler to the nearest millimetre before being released into the sanctuary grounds at the site from where their dam was first caught and later released.

RESULTS

The weight and length of the four female weasel skinks at capture are presented in Table 1.

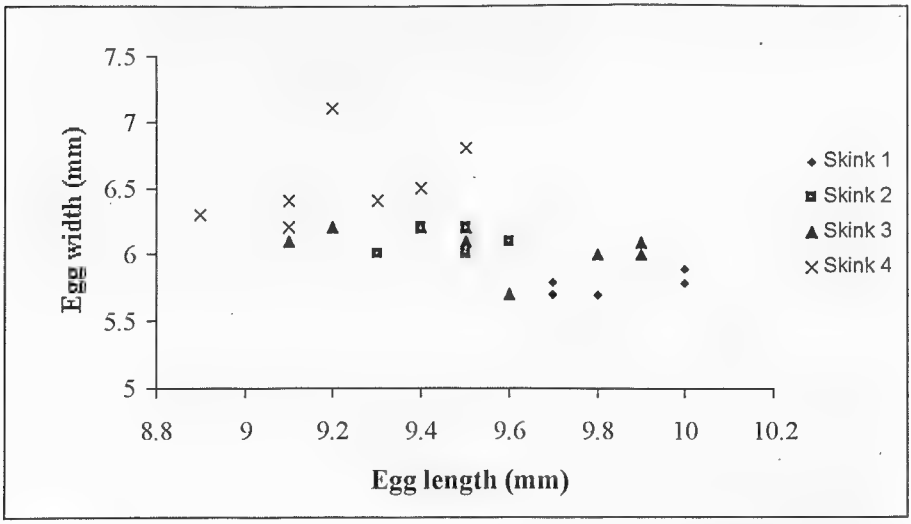
Table 1. Measurements of the adult Weasel Skinks and the number of eggs laid by each (* regenerated tail).

Skink	SV length (mm)	Total length (mm)	Gravid weight (g)	No. of eggs laid	Post-lay weight (g)	Weight loss (%)
1	50	137	2.9	5	1.9	34
2	49	134	2.8	5	1.8	36
3	64	120*	4.5	9	2.6	42
4	59	135*	4.7	7	3.3	30

All four female skinks laid within 15 days of capture. Female 3 laid a clutch of nine eggs overnight on December 5-6, female 4 laid seven eggs overnight on December 11-12 and females 1 and 2 both laid five eggs on the night of December 23-24. Skink 2 laid the eggs in a scooped out shallow depression on top of the substrate, beneath the piece of bark, while the remaining three females laid their clutches more deeply in the substrate (2 of these laid in vermiculite) in a bottom corner of their containers.

Twenty-four eggs weighed 0.2 g while the remaining two eggs (from female 4) weighed 0.3 g each. Females 1 and 2 lost 1.0 g each, which corresponded to the total weight of their egg mass of 1.0 g. Female 3 lost an extra 0.1 g and female 4 gained 0.2 g compared to total mass of her clutch (this was the clutch that registered 2 eggs at 0.3 g). The width and length of the 26 eggs is displayed in Figure 1.

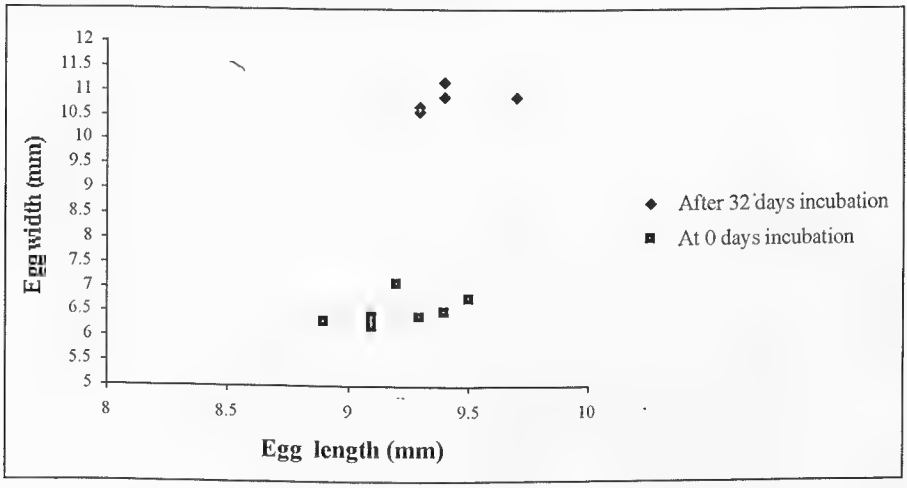
Figure 1. Length and width measurements of the eggs from the weasel skink clutches immediately after laying (two eggs from skink 3 were identical in size to skink 4 and therefore do not show on the graph: 6.2x9.4 and 6.2x9.5)



The average length of the weasel skink eggs was 9.50±0.30mm, while the average width was 6.14±0.32mm.

The eggs swelled enormously soon after they were laid, becoming almost spherical in shape. It is known that reptile eggs take on large volumes of water during the incubation, which the embryo needs for metabolic processes and growth (Shine, 1998). The clutch of eggs from female 4 was weighed and measured after one of the eggs hatched after 32 days of incubation. Figure 2 shows the dimensions of the six remaining eggs alongside the initial dimensions recorded for all seven eggs immediately after laying. These remaining six eggs all hatched later in the day.

Figure 2. Measurement comparisons between the same clutch of eggs at laying date and at 32 days incubation.



The mass and measurements of incubated eggs increased by 0.3-0.4 g in weight, and an average of 2.9 mm in width and 1.6 mm in length over the incubation period.

After an incubation period of 31-32 days for clutches 1, 2 and 4, and 35-37 days for clutch 3, a total of 24 hatchlings emerged. Two eggs from clutch 1 failed to hatch – upon dissection this was due to the absence of a developing neonate, suggesting they were infertile. At the time of hatching, all hatchlings weighed 0.2 g and were between 19-21 mm S-V length and 45-52 mm total length (Table 2), indicating considerable variation in the length of the tail between individuals.

DISCUSSION

Clutch size in *Saproscincus mustelinus* is variable, and believed to be correlated to the size of the female (Greer, 1989). Clutches of two to seven eggs have been recorded, with an average of 3.7 (Greer, 1989). The published snout-vent length for adult Weasel Skinks is between 39 mm and 62 mm, with an average length of 45-48 mm (Greer, 1989; Wilson & Knowles, 1992). The female *S. mustelinus* in this study ranged from 49-64 mm with a clutch size of 5 – 9, increasing with the size of the female, supporting the hypothesis that clutch size is relative to female size. It is interesting to note that one of the skinks in this study (skink 3) had an S-V length of 64 mm, longer than previously

Table 2. Measurements of the hatchling Weasel Skinks.

Skink	S-V length (mm)	Total length (mm)
1	19	45
2	19	46
3	19	47
4	19	45
5	20	49
6	19	45
7	19	45
8	20	47
9	22	54
10	22	55
11	22	54
12	21	51
13	21	52
14	21	53
15	22	55
16	22	55
17	21	53
18	21	52
19	22	52
20	22	53
21	21	53
22	21	52
23	22	53
24	21	52
Average	20.8	50.8
St.dev	1.2	3.6

recorded, and produced a larger clutch (nine) than previously documented for this species. I also note that the eggs from the four collected females varied greatly in size, with some females laying elongated eggs, while others producing more spherical eggs.

The egg weights recorded in this study are similar to those recorded by Ehmann (1988) and Banks (1992) of 0.17 g and 0.31 g respectively.

It may be coincidence, but it is worth noting that the female skinks, which were found in the same area, all laid eggs overnight.

The incubation period for the Weasel Skink in this study was 31-32 days for three clutches and 35-37 days for the other clutch. This incubation period is comparable to the incubation period exhibited by the closely related *Lampropholis delicata* and *L. guichenoti* when incubated at 26°C (Shine, 1983).

There is very little variation in the measurements of the hatchling skinks, with the average weight, snout-vent length and total length being comparable to those recorded by Banks (1992). However the average total length is longer than the average recorded by German (1980) of 41 mm.

ACKNOWLEDGMENT

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A RECORD OF SCALELESS DEATH ADDERS, *ACANTHOPHIS ANTARCTICUS*

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Death Adders in Australia consist of four recognised species of live-bearing, highly venomous elapid snakes, the Common Death Adder (*Acanthophis antarcticus*), Desert Death Adder (*Acanthophis pyrrhus*), Northern Death Adder (*Acanthophis praelongus*) and Pilbara Death Adder (*Acanthophis wellsi*) (Cogger, 2000). The Common Death Adder is widely distributed in eastern and southern Australia, and is the largest species, occasionally exceeding 1 m in total length.

Death Adders are viviparous with maximum recorded litter sizes of 20, 33 and 42 (Cogger, 2000; Wilson & Knowles, 1992; Covacevich *et al.*, 2000 respectively). Mating in captive animals in Brisbane has occurred from September to November, with males showing most interest in mating in mid to late October, and births usually occurring in late February (pers. obs.).

In mid-October 2002, two recently sexually mature *A. antarcticus* in my collection were placed together. The male showed immediate and sustained interest in mating, and copulation was observed on numerous occasions. This behaviour persisted until late October, then ceased abruptly.

The female was maintained in a plastic stowbin with a floor area of 40 x 75 cm, and a heat mat placed underneath one end. Cage floor temperature above the heat mat was 39-40°C. During very warm weather, she stayed at the opposite end of the cage from the heat source and moved to the heated end only at night. The female continued to feed, which is normal (at least during the early stages of pregnancy), and first refused food on 17 January 2003, by which time her abdomen was obviously distended and she tended to rest in an outstretched position.

Twenty-three live young were born on 5 February 2003, together with one infertile ovum. Unusually bright bands were visible on six individuals through the amniotic membranes, and after breaking free, these were observed to have no dorsal body scales. Only ventral scales, subcaudals, anal, infralabials, rostral, nasals, a few supralabials and a few small scales above the eyes were present (Figure 1). This unusual scalation is more or less identical on all six snakes.

These aberrant neonates appear to be vigorous. All neonates (and the mother) were weighed 2 days post-partum. The "scaleless" snakes were on average slightly heavier than the normal ones (Table 1). The total clutch weight was just slightly over half the mother's post-partum body weight, but does not include amniotic tissue and fluids and the infertile ovum.

Table 1. Mass (g) of neonate *Acanthophis antarcticus* at 2 days.

	Scaled	Unscaled
Range	3.83-6.32	5.00-6.78
Mean	5.59	5.68
Standard deviation	0.612	0.625
Sample size	17	6
Total clutch mass		129
Maternal mass		257

The scaleless condition, scale agenesis (Rossi, 1996), has been noted in seven North American snakes: six colubrids from five genera, and one viperid, the Western Diamondback Rattlesnake (Bechtel, 1995). Most records are derived from multiple generations of captive breeding probably resulting in significant inbreeding, although scaleless wild caught snakes have been reported. Bechtel and Bechtel (1991) demonstrated that scale agenesis in Texas Rat Snakes (*Elaphe obsoleta lindheimeri*) was the result of a single autosomal recessive gene. The proportion of "scaleless" snakes in the Death Adder litter (6/23) is consistent with the trait being the result of a single autosomal recessive gene.

Detailed accounts of "scaleless" snakes, with photographs, are given in Bechtel (1995). His general description of these snakes closely matches the characters of the six "scaleless" Death Adders. The skin has the "appearance and texture of a naked, newborn mouse" (p. 93). He also states that the snakes "move and feed normally, but ... have difficulty shedding since the cast is very thin and ... rolls into a tight band at the thick mid-section of the snake." (p. 95). This is consistent with these Death Adders. At one to two weeks of age all the neonates sloughed their skinks, and each "scaleless" neonate exhibited problems sloughing as described above.

The "scaleless" snakes are all feeding normally as of the date of writing.

ACKNOWLEDGMENTS

I thank Keiran Aland for suggesting improvements to the text. Thanks also to Patrick Couper, Heather Janetzki and Andrew Amey at the Queensland Museum, who assisted with the key reference (Bechtel, 1995) and the loan of accurate scales for weighing the neonates.

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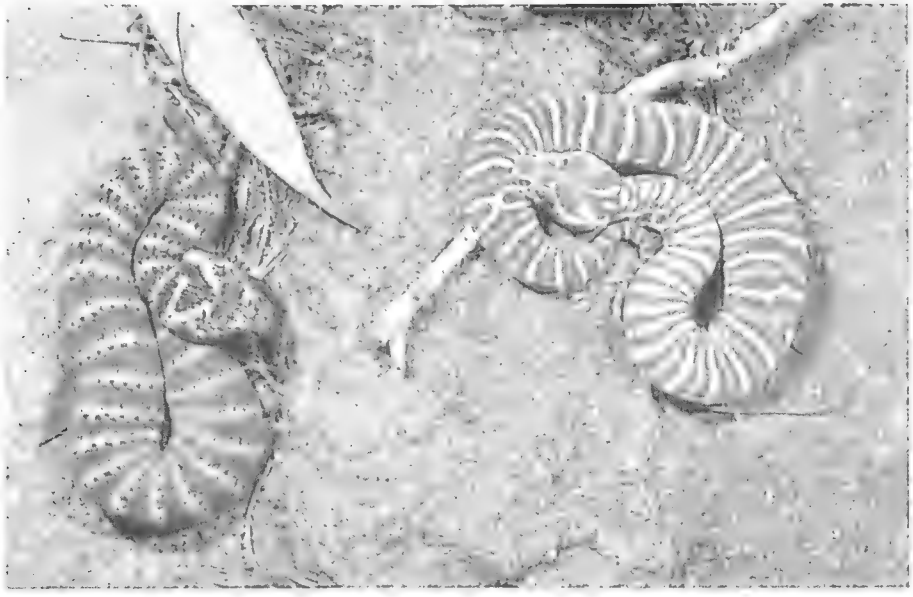
Figure 1. Detail of one of the neonate *A. antarcticus* exhibiting scale agenesis. Age 36 days.

Figure 2. Siblings from the same clutch: left, a normal juvenile *A. antarcticus*; right, juvenile with scale agenesis. Age 36 days.



ADDITIONAL DATA ON CAPTIVE REPRODUCTION OF THE PALE-HEADED SNAKE, *HOPLOCEPHALUS BITORQUATUS* (JAN, 1859)

Brian Lazell
53 Curtin St, Cabramatta, NSW 2166

The Pale-Headed Snake (*Hoplocephalus bitorquatus*) is one of three species in the genus *Hoplocephalus*. Until recently, the ecology of all three species was poorly known (Shine, 1983), although there have been recent field studies of the two species with the most limited distributions, the Broad-headed Snake, *Hoplocephalus bungaroides* (Webb and Shine, 1997a-b, 1998a-c, 2000; Webb *et al.*, 2002; Shine *et al.*, 1998) and Stephens' Banded Snake, *Hoplocephalus stephensii* (Fitzgerald *et al.*, 2002a-b). In contrast, the more widely distributed Pale-Headed Snake remains little studied.

Lazell (2000, 2001) reported data on timing of reproduction, parturition and neonate size for seven litters from six captive female Pale-Headed Snakes. The current paper reports another five captive-bred litters, and summarises the data from all 12 litters, including some additional data for the previous seven litters.

REPRODUCTIVE DATA FOR FIVE NEW LITTERS

Table 1. Maternal and parturition data for five litters of Pale-Headed Snakes. Relative clutch mass 1 is ratio of maternal mass loss to post-birth maternal mass; relative clutch mass 2 is ratio of litter mass to post-birth maternal mass.

	Litter 8	Litter 9	Litter 10	Litter 11	Litter 12
Snout-vent length (SVL)	630 mm	500 mm	580 mm	530 mm	620 mm
Tail length (TL)	105 mm	85 mm	90 mm	83 mm	100 mm
Placed with male	24 Mar 2001	24 Mar 2001		6 Sep 2001	12 Apr 2000
Observed matings	19 May 2001 (1600hrs)	25 Mar 2001			28 Feb 2001
Last shed pre-birth	11 Dec 2001	30 Nov 2001		21 Dec 2001	5 Dec 2001
Mass (16 Dec) Last fed Meal	116 g 10 Nov 2001 1 small mouse	82 g 25 Oct 2001 1 small mouse	92 g not recorded	75 g 10 Nov 2001 1 small mouse	86 g 10 Nov 2001 1 small mouse
Mass (2 Jan) Last fed Meal	122 g 16 Dec 2001 1 small mouse	84 g 25 Oct 2001	93 g not recorded	76 g 16 Dec 2001 1 small mouse	91 g 16 Dec 2001 1 small mouse
Mass (28 Jan) Last fed Meal	121 g 16 Dec 2001	88 g 25 Oct 2001	94 g not recorded	77 g 16 Dec 2001	94 g 9 Jan 2002 1 small mouse

Mass (16 Feb) Last fed Meal	129 g 28 Jan 2002 1 small mouse	90 g 25 Oct 2001	95 g not recorded	80 g 16 Dec 2001	105 g 10 Feb 2002 1 rat pup*
Mass (24 Feb) Last fed Meal	131 g 28 Jan 2002	94 g 25 Oct 2001	97 g not recorded	81 g 16 Dec 2001	108 g 10 Feb 2002
Mass (3 Mar) Last fed Meal	141 g 28 Feb 2002 1 adult mouse	94 g 25 Oct 2001	96 g not recorded	81 g 16 Dec 2001	116 g 28 Feb 2002 1 small mouse
Mass (16 Mar) Last fed Meal				81 g 16 Dec 2001	113 g 28 Feb 2002
Mass (20 Mar) Last fed Meal					111 g 28 Feb 2002
Food offered, not taken	9 Jan 2002 11 Jan 2002	3 Nov 2001 10 Nov 2001 16 Dec 2001 9 Jan 2002 11 Jan 2002 28 Jan 2002 28 Feb 2002	16 Dec 2001 23 Dec 2001 9 Jan 2002 28 Jan 2002 10 Feb 2002 28 Feb 2002	9 Jan 2002 11 Jan 2002 28 Jan 2002 28 Feb 2002	Nil
Date of birth	Between 4-15 Mar 2002	Between 4-15 Mar 2002	Between 4-15 Mar 2002	19 Mar 2002	25 Mar 2002
Litter size	5	4	4	4	5
Female mass (after birth)	87 g	48 g	56 g	47 g	73 g
Litter mass	40 g	35 g	31 g	21 g	29 g
Female mass loss post-birth	6 g ** (assuming pre-birth mass of 133g)	11g	9g	13g	9g
Relative Clutch Mass 1	0.52	0.95	0.71	0.72	0.52
Relative Clutch Mass 2	0.45	0.72	0.55	0.44	0.39

*Also ate one small mouse 28 Jan 2002.

**Assuming pre-birth mass of 133 g (reduced from 141 g due to large mouse eaten 3 days before weighing)

The precise date of birth for litters 8-10 is not known, but was possibly 13 March, 13 March and 7 March respectively. At the time of birth of the first snake of litter 11, the air temperature was 28°C and the relative humidity was 61%. For litter 12, the four observed births occurred at air temperatures of 27-29°C.

Table 2. Neonate data

Litter	Neonate	Time of birth	SVL (mm)	TL (mm)	Mass (g)	Sex	First Slough
8	1	not known	220	35	8	F	26 Mar
	2		225	40	8	M	25 Mar
	3		225	42	8	M	25 Mar
	4		225	37	8	F	25 Mar
	5		225	36	8	F	26 Mar
	mean		224.0	38.0	8.0		
9	1	not known	220	41	8	M	25 Mar
	2		235	45	9	M	26 Mar
	3		230	40	9	F	25 Mar
	4		230	47	9	F	26 Mar
	mean		228.8	43.3	8.8		
10	1	not known	235	37	7	M	19 Mar
	2		240	42	8	M	19 Mar
	3		245	40	9	F	19 Mar
	4		230	32	7	F	19 Mar
	mean		237.5	37.8	7.8		
11	1	1300hrs	235	34	7	F	4 Apr
	2	1530-1730hrs	225	42	6	M	6 Apr
	3*	1530-1730hrs	175	31	3	?	-
	4	2100-0800hrs	220	37	5	M	5 Apr
	mean		213.8	36.0	5.3		
12	1	<0800hrs	205	40	6	M	8 Apr
	2	1125hrs	233	39	7	F	11 Apr
	3	1240hrs	225	38	5	F	11 Apr
	4	1310hrs	210	36	6	F	8 Apr
	5	1355hrs	205	36	5	F	9 Apr
	mean		215.6	37.8	5.8		

*Found dead in embryonic sac – possibly too weak to break from sac.

Additional data on litters 1-7 (reported by Lazell 2000, 2001).

Litter 1: Maternal SVL 600 mm. Last slough prior to parturition 17 Nov 1999. Date placed with male 20 Oct 1999, attempted mating observed 24 October 1999.

Litter 2: Maternal SVL 620 mm. Last slough prior to parturition 19 Nov 1999. Neonate 3 from this litter is male.

Litter 3: Maternal SVL 610 mm. Last slough prior to parturition 26 Nov 1999. Attempted mating observed 9 Apr 1999. Neonate 1 from this litter is male.

Litter 4: Maternal SVL 680 mm. Last slough prior to parturition 22 Nov 2000. Female placed with male 12 Apr 2000. Neonates 4 and 6 from this litter are females.

Litter 5: Maternal SVL 620 mm. Last slough prior to parturition 29 Nov 2000, Mating observed 13 May 2000.

Litter 6. Maternal SVL 460 mm. Last slough prior to parturition 2 Dec 2000.

Overall summary for 12 litters

Tables 3 and 4 give the pooled data for the five litters reported here and the seven litters reported previously. Data for some variables (pre-birth mass, RCM1, interval between last feed and parturition, interval between last shed and parturition) for some litters are not included in the statistics because precise values are not known, but using the estimated dates of birth for litters 8-9 and the estimate of pre-parturition maternal mass for litter 8 gives values for pre-birth mass, RCM1 and last shed to parturition for both snakes within the known range of variation. The interval between last feed and estimated date of parturition in litter 9 is 139 days, and definitely between 141 and 130 days, the highest value in this study.

For neonate data (SVL, TL, mass), the values for the abnormally small dead neonate in litter 11 were removed. For days to first slough, because only the maximum was recorded for litters 1-7, and imprecise values are known for litters 8-10, the summary statistics are only for maximum values per litter, and exclude litters 8-10.

Table 3. Summary statistics for 12 litters of Pale-Headed Snakes. Sample size refers to the number of adult snakes (for maternal data, litter size and mass, with data from the same female in two successive years treated as two data points) or number of neonates (for neonate data).

	Range	Mean	Standard Deviation	Sample Size
Maternal SVL	460-680 mm	586.4 mm	64.39 g	11
Maternal TL	77-110 mm	92.7 mm	9.93 g	11
Mass before birth	59-135 g	102.8 g	23.27 g	10
Mass after birth	39-88 g	64.5 g	16.90 g	11
Clutch Mass	12.5-40 g	27.3 g	9.48 g	12
Relative Clutch Mass 1	0.51-0.96	0.66	0.14	10
Relative Clutch Mass 2	0.23-0.73	0.45	0.13	11
Last Meal to Parturition	3-93 days	26.8 days	28.40 days	10
Last slough to Parturition	88-110 days	93.8 days	7.21 days	8
Litter size	2-6	4.1	1.31	12
Neonate SVL	200-245 mm	221.8 mm	10.65 mm	48
Neonate TL	30-47 mm	37.1 mm	3.82 mm	35
Neonate mass	5-9 g	6.8 g	1.23 g	48
Maximum days to first slough	10-18 days	13.6 days	2.88 days	8

Table 4. Neonate measurements partitioned by sex

	Range	Mean	Standard Deviation	Sample Size
SVL (male)	205-240 mm	226.4 mm	9.51 mm	11
TL (male)	37-45 mm	40.7 mm	2.55 mm	9
Mass (male)	5-9 g	7.2 g	1.25 g	11
SVL (female)	205-245 mm	224.1 mm	11.45 mm	14
TL (female)	32-47 mm	37.0 mm	3.76 mm	14
Mass (female)	5-9 g	7.2 g	1.37 g	14

DISCUSSION

The observations of mating in late summer and autumn suggests that sperm production in this species is asynchronous with the female reproductive cycle, and that females store sperm over winter, as is reported for some related species of Australian elapids (Shine, 1977). However, as litter 11 was produced by a snake that could not have been mated earlier than spring, mating may occur at both times of the year in this species.

A reduction in feeding has been reported in gravid snakes of a number of species (Shine, 1978). Such a loss of interest in feeding was apparent in some gravid *H. bitorquatus*, but not all. Although Shine attributed this in part to the common occurrence of shedding during gestation, most snakes did not shed during the 3 months before parturition.

The clutch size from captive bred Pale-headed Snakes differs slightly from that presented for wild-caught snakes by Shine (1983). While average litter size was similar (4.1 *vs* 4.7), the maximum was noticeably less (6 *vs* 11). This may be due to maternal size. Shine (1983) found a correlation between litter size and maternal SVL, and the largest female in this study had SVL 680 mm, compared with the largest female reported of 780 mm (Shine, 1983).

Neonate size from captive bred litters is a little larger (mean 224 mm) than the 200 mm estimated by Shine (1983).

Data on relative clutch mass are few for elapid snakes (White *et al.*, 1995). The RCM values reported here are intermediate between the values reported for *Drysdalia coronoides* and *Hemiaspis signata* by White *et al.* (1995), two species with litter sizes similar to or slightly larger than for *H. bitorquatus*. The mean value for *H. bitorquatus* is higher than the single value reported for *Hoplocephalus bungaroides* by Shine and Fitzgerald (1989), although the range of variation for *H. bitorquatus* includes the value for the latter species. Excluding data for *Hoplocephalus*, the mean RCM2 for 44 individuals of 18 Australian elapid snakes tabulated by Greer (1997) was 0.51. Hence, the data for *Hoplocephalus* are slightly lower than average for Australian elapids.

ACKNOWLEDGMENTS

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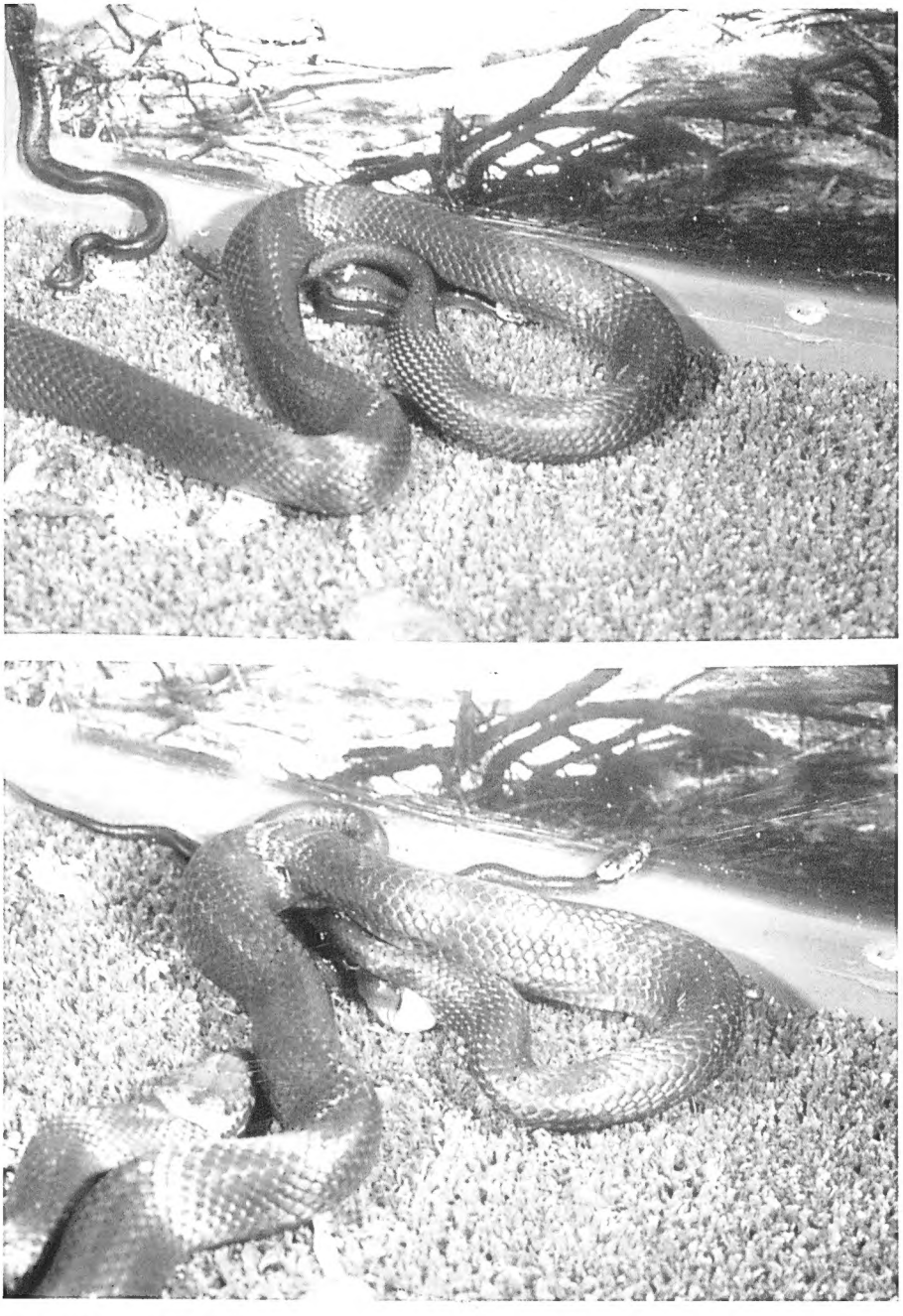
Figures 1-2. Pale-headed snake giving birth.



BOOK REVIEW

THE AMPHIBIANS AND REPTILES OF COSTA RICA. A HERPETOFAUNA BETWEEN TWO CONTINENTS, BETWEEN TWO SEAS

By Jay M. Savage with Photographs
by Michael Fogden and Patricia Fogden, 2002
xx + 934 pp., 516 colour plates, 396 maps, 335 line drawings, 36 tables
Published by The University of Chicago Press, Chicago and London
R.R.P. $US75.00. ISBN 0-226-73537-0

Herpetology in the 20th Century was characterised by several unique features, unlikely ever to be seen again. It was a time when major habitat degradation was gathering pace but had not yet reached the wide scale of the present; it was when almost any species could be collected in any numbers within little or no legal authorisation; it was when science was entering its "modern" phase, and it was when travel to the remotest parts of the world was relatively inexpensive and safe. In this charmed century, there have been roughly three generations of herpetologists, each with its own special characteristics. The first generation, in contrast to the museum-bound herpetologists of the preceding century, travelled extensively in their chosen geographic areas and added field data to specimen data to an unprecedented degree. The second generation coincided largely with the technological boom and financial wealth following WW II. And the third generation watched the transition to the modern (or should that be "post-modern"?) era noted primarily for its exponential rates of habitat destruction and species decline with a resulting emphasis on pathetically futile and politically distracting "conservation biology" research; research agendas controlled ultimately by bureaucrats and politicians, and highly specialised job requirements where a cookbook knowledge of molecular biology, and not of animals, is the single most important line item in an application.

What relevance does this have to a book review? Well, the author of the book under review was a member of the middle generation, a generation that looks increasingly likely to be regarded as the luckiest in the entire history for herpetology. And Jay Savage's book, The Amphibians and Reptiles of Costa Rica, represents the best of the thorough and painstaking research for which that generation is becoming increasingly noted. I will not go into the details of the book other than to say it is huge, comprehensive, well illustrated and extraordinarily cheap. And I will certainly not pick nits. I will simply say that if this book does not awe you, you have no capacity to appreciate the creativity of life-long scholarship.

But this book represents something even more than a summary of a major area of research of one person. As time passes, it will become an important part of the pathetically small collection of material objects that will offer small insights into what the natural world was like before humans destroyed it. Books, specimens, photographs, films, notes, recordings and some depauperate "natural" reserves will be all there is. And even these will be ravaged by time unless we take precautions. In fact, at this moment, specimen tags and inks, perhaps the weakest link in this whole remembrance of things past, are slowly disintegrating with little notice being taken. And so will books such as the one that Jay Savage has given us, if we're not careful.

So, thanks Jay. You are one of the best of a remarkable cohort. You had some unique opportunities and you made the most of them. Herpetology won't see your likes again.

Allen E. Greer
Herpetology Section
Australian Museum
6 College St Sydney, NSW 2010

NOTES TO CONTRIBUTORS

Herpetofauna publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – black and white prints or colour slides are acceptable.

Use a recent issue of Herpetofauna as a style guide.

A computer disc may be submitted instead of hard copy but this should not be done until after the manuscript has been reviewed and the referees' comments incorporated. Computer discs must be HD 1.44 mb 3.5" in Word for Windows; Wordperfect; Macintosh or ASCII. Any disc must also be accompanied by hard copy.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

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Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

Significant changes will require the article to be revised and a fresh manuscript submitted.

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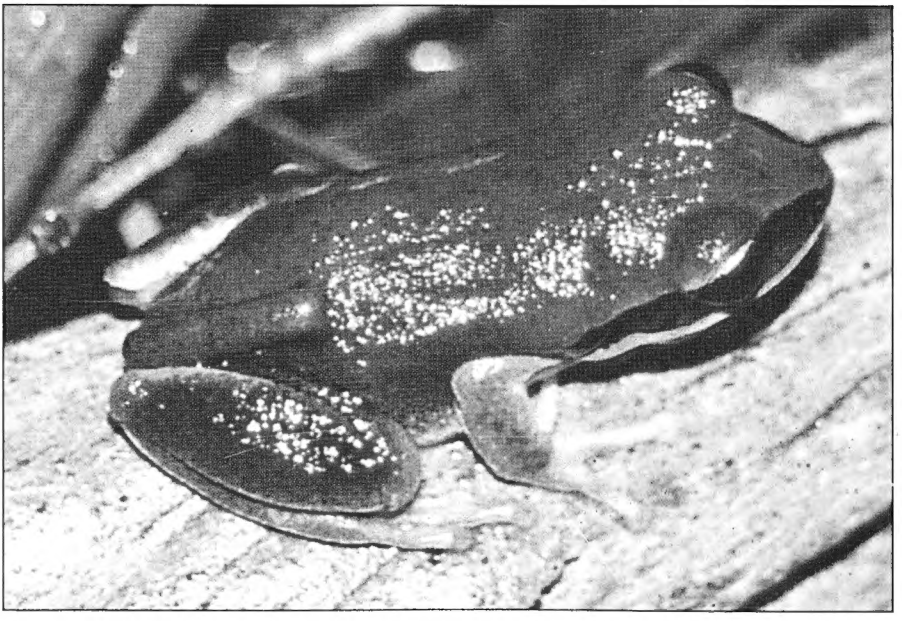
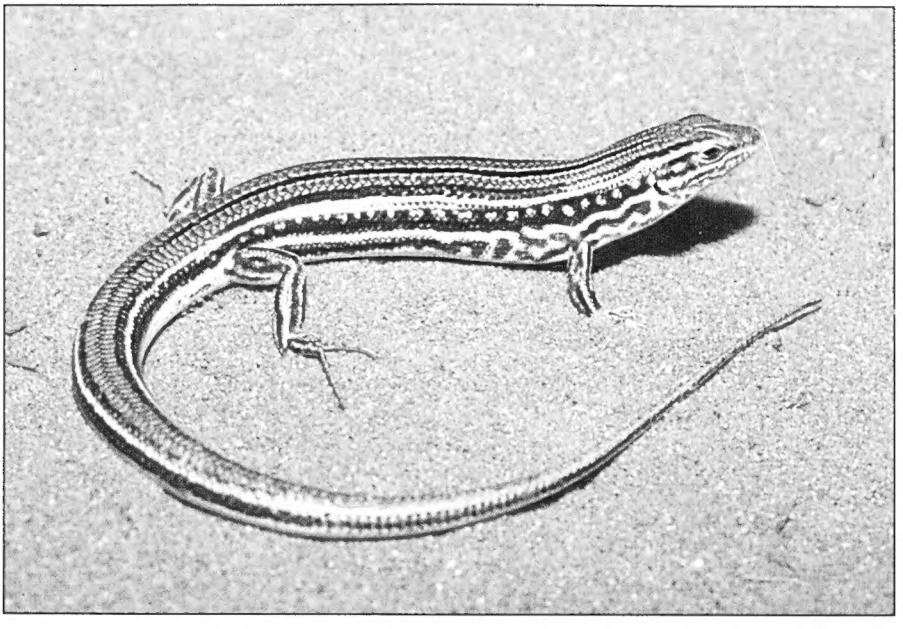


Adult male Green-thighed Frog (*Litoria brevipalmata*) from Buladelah, NSW with pit-tag.
See paper on page 13. (Photo by F. Lemckert).



Regal Skink (*Ctenotus regius*) from Menindee Lakes, NSW
See paper on page 37. (Photo by G. Brown).